NEIL ABERCROMBIE
GOVERNOR OF HAWAII

WILLIAM J. AILA, JR.
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

ESTHER KIA'AINA
FIRST DEPUTY

WILLIAM M. TAM
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

July 8, 2013

FILE COPY

Office of Environmental Quality Control
Department of Health, State of Hawai'i
235 S. Beretania Street, Room 702
Honolulu, Hawai'i 96813

JUL 23 2013

Dear Director,

With this letter, the Department of Land and Natural Resources hereby transmits the draft environmental assessment (DEA) and anticipated finding of no significant impact for the Kaupakuea Orchards LLC Forest Stewardship management plan and project situated at tax map key numbers (3) 2-8-003:009 and 010 in the South Hilo District on the island of Hawaii for publication in the next available edition of the Environmental Notice.

Enclosed is a complete OEQC Publication Form, two copies of the DEA and compact disk containing a PDF file of the draft environmental assessment and an electronic copy of the publication form in MS Word.

If there are any questions, please contact Irene Sprecher with Department Land and Natural Resources Division of Forestry and Wildlife at (808) 587-4167 or by email at Melissa.I.Sprecher@hawaii.gov.

Sincerely,

Esther Kiaaina for

William J. Aila, Jr.
Chairperson

RECEIVED
'13 JUL 11 A9:24
OFC. OF ENVIRONMENTAL
QUALITY CONTROL

APPLICANT ACTIONS
SECTION 343-5(C), HRS
PUBLICATION FORM (JANUARY 2013 REVISION)

Project Name: Kaupakuea Orchards LLC Forest Management Plan, State of Hawaii Forest Stewardship Program
Island: Hawaii
District: South Hilo
TMK: (3) 2-8-003-009 and (3) 2-8-003-010
Permits: n.a.
Approving Agency:
Department of Land and Natural Resources, Post Office Box 621, Honolulu, Hawaii 96809
Contact: Division of Forestry and Wildlife, 1151 Punchbowl St. Room 325, Honolulu HI 96813
Irene Sprecher 808-587-4167
Applicant:
Christopher Trimarco, P.O. Box 98, Pepeekeo, HI 96783 954-650-0967
Consultant:
Forest Solutions, P.O. Box 2037, Kamuela HI 96743, Tom Baribault, Nick Koch 808-776-9900
Status (check one only):

X DEA-AFNSI	Submit the approving agency notice of determination/transmittal on agency letterhead, a hard copy of DEA, a completed OEQC publication form, along with an electronic word processing summary and a PDF copy (you may send both summary and PDF to oeqchawaii@doh.hawaii.gov; a 30-day comment period ensues upon publication in the periodic bulletin.
__FEA-FONSI	Submit the approving agency notice of determination/transmittal on agency letterhead, a hard copy of the FEA, an OEQC publication form, along with an electronic word processing summary and a PDF copy (send both summary and PDF to oeqchawaii@doh.hawaii.gov; no comment period ensues upon publication in the periodic bulletin.
__FEA-EISPN	Submit the approving agency notice of determination/transmittal on agency letterhead, a hard copy of the FEA, an OEQC publication form, along with an electronic word processing summary and PDF copy (you may send both summary and PDF to oeqchawaii@doh.hawaii.gov; a 30-day consultation period ensues upon publication in the periodic bulletin.
__Act 172-12 EISPN	Submit the approving agency notice of determination on agency letterhead, an OEQC publication form, and an electronic word processing summary (you may send the summary to oeqchawaii@doh.hawaii.gov. NO environmental assessment is required and a 30-day consultation period upon publication in the periodic bulletin.
__DEIS	The applicant simultaneously transmits to both the OEQC and the approving agency, a hard copy of the DEIS, a completed OEQC publication form, a distribution list, along with an electronic word processing summary and PDF copy of the DEIS (you may send both the summary and PDF to oeqc@doh.hawaii.gov); a 45-day comment period ensues upon publication in the periodic bulletin.
__FEIS	The applicant simultaneously transmits to both the OEQC and the approving agency, a hard copy of the FEIS, a completed OEQC publication form, a distribution list, along with an electronic word processing summary and PDF copy of the FEIS (you may send both the summary and PDF to oeqc@doh.hawaii.gov); no comment period ensues upon publication in the periodic bulletin.
__ Section 11-200-23 Determination	The approving agency simultaneous transmits its determination of acceptance or nonacceptance (pursuant to Section 11-200-23, HAR) of the FEIS to both OEQC and the applicant. No comment period ensues upon publication in the periodic bulletin.
__Statutory hammer Acceptance	The approving agency simultaneously transmits its notice to both the applicant and the OEQC that it failed to timely make a determination on the acceptance or nonacceptance of the applicant's FEIS under Section 343-5(c), HRS, and that the applicant's FEIS is deemed accepted as a matter of law.
__Section 11-200-27 Determination	The approving agency simultaneously transmits its notice to both the applicant and the OEQC that it has reviewed (pursuant to Section 11-200-27, HAR) the previously accepted FEIS and determines that a supplemental EIS is not required. No EA is required and no comment period ensues upon publication in the periodic bulletin.
__Withdrawal (explain)	

Summary (Provide proposed action and purpose/need in less than 200 words. Please keep the summary brief and on this one page):

The Kaupakuea Orchards LLC riparian restoration and hardwood timber project Forest Management Plan was approved by the State of Hawaii Forest Stewardship Advisory Committee at their most recent meeting on May 10th 2013.

In brief, the plan has two distinct components which, combined, should significantly improve the subject property and adjacent areas. The land is in a severely degraded condition. Many years of sugar cane production followed by subsequent small scale ginger farming and cattle grazing has taken a toll on the soil and decimated native plant life.

The project will include TMKs (3) 2-8-003:009 and :010. The total property is approximately 40 acres mauka of Pepeekeo on the Big Island. It's bordered by Kaupakuea Homestead Road to the north and the year around Waiaama Stream to the south.

The stream bank has been entirely taken over by invasive Guavas that have choked off virtually all native plant life. Approximately 850'-900' of stream bank (4.4 acres) will have all Guava eradicated and be replanted with native ferns and Ohia.

The other significant feature of the FMP is to establish a mix of non-invasive tropical hardwood trees and native hardwood trees on what is now 18 acres of pasture land of mixed alien grasses.

Environmental Assessment

FOR

State of Hawaii

Forest Stewardship Program

Cost Sharing Grant

FOR A

Riparian Restoration

and

Timber Production Project

Pepeekeo, Hawai'i

TMK (3) 2-8-003:009

TMK (3) 2-8-003:010

Released for public review:

July 23, 2013

Prepared by:
Thomas Baribault
Research Forester
Forest Solutions, Inc.
P.O. Box 2037
Kamuela, HI 96743

On behalf of:
Kaupakuea Orchards, LLC

Table of Contents

1. PROJECT SUMMARY

Project Name:	Riparian Restoration and Timber Production Project
Applicant:	Kaupakuea Orchards, LLC (KOL)
Approving agency:	Department of Land and Natural Resources (DLNR) Contact: Division of Forestry and Wildlife (DOFAW)
Requirement for EA:	Seeking cost sharing funds from the State of Hawaii in the form of a Forest Stewardship Grant for restoring native trees in riparian areas and for planting high-value hardwood timber trees to be harvested no earlier than 30 years after planting.
Anticipated determination:	Anticipated Finding of No Significant Impact (AFONSI)
Project Location:	Pepeekeo, Hawaii. The project is located on Kaupakuea Homestead Road, approximately 10 miles north of Hilo, and 1.9 miles mauka from the turnoff from Hawaii Belt Road.
Acreage:	Project proposed for 23.3 acres of a total parcel area of 41.5 acres.
Tax Map Keys:	(3) 2-8-003: 009 and 010
Land Use District:	Agriculture (State, County)
Pre-Consultation:	Nicholas Koch (project consultant, FSI) Thomas Baribault (project consultant, FSI) Office of Hawaiian Affairs DLNR Historic Preservation Division DLNR Division of Forestry and Wildlife County of Hawaii Planning Department Adjacent neighbors

2. PROJECT DESCRIPTION

2.1. Overview

The proposed Forest Management Plan (FMP) would be funded by a cost sharing grant (CSG) with the State of Hawaii (SoH) Forest Stewardship Program (FSP), to be provided by the SoH Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW). The management plan, which is available for public review at the Hilo Public Library, and by request at (808) 776-9900 x 238, conforms to requirements of the Forest Stewardship Program as outlined in the Forest Stewardship Handbook (see **Appendix A**). The main features of this FMP are (1) restoration of riparian areas along the Waiaʻama Stream by removal of invasive species and planting of native species and (2) planting of high-value hardwood trees in abandoned pasture land. The CSG covered by this environmental assessment (EA) covers strictly the first decade of this project, which will involve planting native tree species in the riparian zone and establishing high-value hardwoods in the pasture area. Harvesting of the hardwood trees would not occur within the timeframe of the CSG, and is therefore not the subject of this EA or this FMP. For all restoration, planting, and silvicultural operations, KOL is committed to using best management practices (BMP, see **Appendix B**) endorsed by SoH.

2.2. Project size

The total area encompassed by the two TMK is 41.5 acres, of which 4.4 acres would be dedicated to riparian restoration, and 18.8 acres to hardwood plantings. The remaining acreage encompassed by the two TMKs will be dedicated to a single family home(s), farm buildings, and various agricultural activities. Small scale, non-commercial, fruit orchards, vegetable growing, and ornamental horticulture are anticipated. This area, and the described activities, are not involved with the FMP, are not an element of the CSG request, and do not fall under the scope of this EA.

2.3. Project duration

Although the high value timber element is at least a 30-year project, a CSG is sought only for the first ten years of the project. During this time, timber plantings would be completed within the first three years, with cost sharing for maintenance through the fifth year of the project. Native forest restoration in the riparian areas along Waiaʻama Stream would continue for the duration of the project, through the tenth year.

2.4. Environmental Assessment

According to the Forest Stewardship Handbook and rules of the FSP, an EA is required for projects in which SoH CSG funding is sought. In particular, “Plans that include the establishment of timber with the intent of eventual harvest [regardless whether harvest occurs during the cost sharing phase of the plan] and projects involving fencing an area over 10 acres must be accompanied by an Environmental Assessment (EA), HRS §343.” This FMP involves both eventual harvest as well as more than 10 acres of area to be fenced, thus triggering the EA requirement under FSP rules. Elements of the Forest Management Plan that concern riparian restoration are not described in detail in this document. The riparian buffer restoration activities are covered under the DLNR Department of Forestry and Wildlife’s allowed exemption classes dated June 12,2008. Particularly, Exemption Class 1 number 8 and 9, and

Exemption Class 4 number 6 and 7. Only the 18.8 acres that are to be planted with hardwood trees fall under the scope of this EA.

2.5. Cost Sharing Grant

The duration of the project for which SoH funding is sought is ten (10) years. During this period, KOL seeks a 50% cost sharing for all restoration, establishment, and maintenance operations. Cost sharing for native forest restoration in the riparian areas does not require treatment in this EA; only cost sharing requests for the hardwood plantings are under review in this document.

2.6. Forest management plan

Chief elements of this FMP include restoration and hardwood timber plantings:

- Restore forest cover to the upper elevations of each TMK by establishing plantations of several high value hardwood species (see map, **Appendix C**).
- Protect and expand the existing native forest cover in streamside management zones (SMZ) by controlling invasive weed species (see map, **Appendix C**).
- Restore portions of the SMZ where invasive species have dominated the ecosystem (see map, **Appendix C**).

The long term goals for this FMP are twofold. First, the project will convert more than 18 acres of marginal pasture land to high value hardwood plantations that can be selection harvested on a 45-year rotation. Hardwood tree species are selected on a combination of criteria. These include, viability of establishment and likelihood of thriving (considering local conditions, like soils, rainfall, elevation, amount of sunshine, etc.). Another criteria is economic viability (seedling availability and costs, market demand for timber, etc.) Trees that meet these criteria must also have acceptable ratings from the State of Hawaii Weed Risk Assessment. There will be positive environmental benefits from the outset of the project that will continue well beyond the harvest period. Due to weed mitigation during the establishment period, ongoing maintenance, and the shade cover created by well established hardwood trees, invasive species will be kept at bay. Also, the chosen selective harvesting method plans for forest cover to remain on the landscape beyond the 45 year rotation period. Per the approved FMP, harvesting will follow the best management practices in place at that time. Second, invasive species in the SMZ, particularly adjacent to Waiaʻama Stream, will be removed and the area restored to a native forest state dominated by ʻōhiʻa (*Metrosideros polymorpha*) in the canopy and native ferns such as uluhe (*Dicranopteris linearis*) and hapuʻu (*Cibotium glaucum*) in the understory. **The project owner, KOL, intends to support this important work in part with a SoH FSP CSG**.

3. Description of site environment

Access to the property from the main highway is via the Kaupakuea Homestead Road. To reach this road when driving North from Hilo, one should pass the 10 mile marker and then turn mauka (left) across from Sugar Mill Road (an important landmark is the large metal gear prominently displayed at this intersection). At the 0.8 mile distance after the left turn is a fork in the road—the left option should be taken, which is a one-lane paved road. On this road, one should travel 1.9 miles, at which

point there is a two-panel farm gate to the left, which is adjacent to utility pole #67. The property access route continues through this gate to the South (toward Hilo), shortly arriving at the concrete box culvert. Project location is also provided in map form (see **Appendix C**).

3.1. Historical land use

The property was owned by various sugar producing companies from 1900 through 1994; conventional sugar cultivation methods were practiced, including subsoil ripping, irrigation, heavy fertilizer and agrochemical use, and controlled burning. These practices implemented over 95 years led to substantial net losses in soil depth and organic matter, and increased compaction. Thereafter, ownership transferred to a private individual, who leased small portions of the property to rotating ginger producers, alternating with ranching, which continues to the present. The larger original property has been subdivided into the Tax Map Key (TMK) featured in this Forest Management Plan (FMP), and the current owner plans to transition from a largely herbaceous vegetation type to a mixture of tree species within the project area.

3.2. Current Forest Condition

The property is typical of abandoned cane land in the Hilo-Honomu area, with only a small minority of the property (2.8 acres, or 7%) currently forested. The forest area is restricted to less than four acres within the larger Streamside Management Zone (SMZ) adjacent to Waiaʻama Stream, with less than an acre of tree cover elsewhere. Native overstory tree species are a minor component of the SMZ, and the only Hawaiian species present is ʻōhiʻa. Several native understory species, chiefly ferns, appear in low numbers among the dominant invasive weed species, which is strawberry guava (*Psidium cattleianum*). An assortment of other weed species are represented to varying degrees, and the pasture area should be considered a completely alien ecosystem dominated by African grasses and assorted broadleaf species. In its current condition, the parcel cannot serve as habitat for any native Hawaiian bird species, or for the Hawaiian bat, all of which require closed canopy forest.

3.3. Existing vegetation and land use

3.3.1. Vegetation cover

The vast majority (37.2 acres, 93%) of the area on the property is currently active pasture land. In the future, intensive pasture will be discontinued on at least 17 acres and likely across the entirety of both parcels. Although the current vegetation cover consists of almost exclusively grasses, without grazing pressure, a suite of non-native woody species would begin to invade. The most likely invaders include common guava (*Psidium guajava*), strawberry guava (*Psidium cattleianum*), faya tree (*Morella faya*), African olive (*Olea europaea subsp.* Cuspidate), tropical ash (*Fraxinus uhdei*), Albizia (*Albizia lebbeck* and *Falcataria moluccana*), and ginger (*Hedychium spp*).

The property supports very limited canopy cover in the SMZ, comprising almost exclusively guava (*Psidium guajava* and *P. cattleianum*) that reach a maximum height of less than 10 m. A few specimens of ʻōhiʻa (*Metrosideros polymorpha*) are present in the Southern SMZ, with several individuals approximately 15 m tall. Also in the Southern SMZ are several areas that contain dead rose apple (*Syzygium jambos*) that was killed after infection with the Myrtaceae generalist rust *Puccinia psidii*. Counter-intuitively, *Psidium spp* are unaffected by

P. psidii, and are the chief species that appear to be replacing *S. jambos* in the canopy. Some seedlings of *F. uhdei* have also escaped from the adjacent State land; these individuals are still juveniles, yet will need to be removed to ensure taxonomic integrity of the SMZ.

The understory of the SMZ property is invaded with smaller strawberry guava almost to the exclusion of native species. Several species of ginger (*Hedychium spp.*) and raspberry (*Rubus spp*) are also present, but grazing has controlled these species to a large extent. In limited sections of the Southern SMZ, dense mats of the Hawaiian native uluhe fern have managed to suppress strawberry guava; unfortunately, this dynamic is a losing battle for the uluhe. The native hapu'u fern (*C. glaucum*) is in the process of being out competed by the guavas.

3.3.2. Adjacent land use

3.3.2.1. Agriculture

Areas directly down slope (makai) from the two TMKs under consideration in this EA are used for agricultural production, including ginger cultivation and pasture. Land use in these adjacent areas can be positively affected by management actions proposed for this project. All site preparation, which will involve machinery, will be conducted according to SoH BMP, and under correct and proper permitting. As such, erosion and runoff will not be encountered. The hardwood forest can serve as a windbreak to the adjacent makai properties as well as reducing the amount of invasive species in the immediate vicinity. The riparian restoration will provide benefits to the adjacent makai properties by improving their upstream water quality.

3.3.2.2. Abandoned land

Areas directly up slope (mauka) from the two project parcels are currently unoccupied and unused for any purpose, whether agricultural, residential, or environmental. Proposed project actions will not affect adjacent mauka parcels.

3.3.2.3. Neighboring land owners

Parcels actively occupied by neighbors, defined as parcels with houses in which persons currently reside, are located only on the Northern side of Kaupakuea Homestead Road, and separated from the property by Ālia Stream and by a belt of tall trees. Planting operations, restoration activities, and the eventual stand of trees on the parcels will not affect neighboring land owners.

3.3.2.4. Fire risk

The property is moist year round, with rainfall in excess of 150 inches evenly distributed throughout the year. Consequently, fire risk is low, and is not expected to pose a threat to the forest investment or to the restoration effort. Furthermore, the streams that define the North and South boundaries provide sources of fire fighting water, while the road at the Eastern edge of the timber compartments serves as a fire break. At the Western edge of the property, open pasture is unlikely to carry any significant fire risk. Thickets of uluhe fern may carry fire in the event of extremely dry and windy conditions that prevail for extended periods, however the total area occupied by uluhe is negligible, and all of this area is adjacent to Waia'ama Stream. Easy access to stream water should allow for any fire to be extinguished quickly.

3.3.3. Soils

A single main soil class, the Kaiwiki hydrous silty clay loam, is represented across the property. A precise description of this soil is derived verbatim from the USDA NRCS Soils Data Viewer, 2011:

The Kaiwiki hydrous silty clay loam component makes up 90 percent of the map unit. Slopes are 5 to 15 percent. This component is on ash fields on lava flows on shield volcanoes on islands. The parent material consists of volcanic ash. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is very high. Shrink-swell potential is very high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 12 percent. This component is in the F159AY500HI Acacia koa-Metrosideros polymorpha-cibotium Menziesii/freycinetia Arborea ecological site. Non irrigated land capability classification is 4e. Irrigated land capability classification is 43. This soil does not meet hydric criteria.

The Kaiwiki soils are on windward mountain slopes with an Eastern aspect. Elevations range from 1,300 to 1,400 feet, and slopes are 0 to 10 percent. The soils formed in volcanic ash. The average January temperature is 66 degrees F.; the average July temperature is 75 degrees F.; and the mean annual soil temperature is 62 degrees F.

Due to a prolonged history of heavy land use by sugar cultivation and rotational ginger production, and continued issues with soil compaction and erosion as a consequence of cattle grazing activities, the soil on the property is marginally productive. There has been some surface erosion due to slope, high rainfall and cattle activity, though this is concentrated along pathways and access roads, and the minor SMZ on the Northern drainage.

3.3.4. Streams and wetlands

One continuous stream (the Waiaʻama Stream) defines the Southern boundary of the property, while an intermittent stream (the Ālia Stream) is located at the Northern boundary. In the center of the Northern parcel is an intermittent drainage bridged by a large concrete box culvert constructed in 1925. Portions of each TMK contain low areas in which water may collect during heavy rains, but these areas do not qualify as streams or wetlands. Technically and functionally there are no wetlands on the property. The slope of the property and steep banks on streams and intermittent drainages prevent water accumulation.

3.4. Historical or cultural resources

Aside from the 1925 historical yet still functional culvert, no unusual or suspect items have been found during comprehensive reconnaissance of the property. A long history of sugar cultivation most likely erased any potentially important historical, cultural, or archaeological signatures; a full archaeological survey has not occurred. However, if during the project, any items are uncovered that are suspected to be of archeological or historical significance, work will be halted and DLNR's State Historic Preservation Department will be contacted as soon as possible.

3.5. Fauna

3.5.1. Non-native fauna

Ground birds, including kalij pheasant (*Lophura leucomelanos*) and wild turkeys (*Meleagris gallopavo*), are frequently observed on the property though their direct impacts on the forest are small; they do carry invasive weed seeds around. Also potentially present are Pueo (*Asio flammeus*) and Io (*Buteo solitarius*). The Hawaiian hoary bat (*Lasiurus cinereus*) is almost certainly not present. The bat may live in the nearby forest, however, and therefore may be encountered in the vicinity. No ʻalalā (Hawaiian crow) sightings have occurred, though the area may have been part of its original habitat. Other native birds common to the area can be found in the ecological site description prepared by the USDA NRCS. Feral pigs (*Sus scrofa*) and escaped domestic cattle (*Bos taurus*) are the largest wildlife threats to establishing forest plantings; a proposed hog-wire fence and gate system should eliminate both cattle and pig disturbance. Cattle are devastating to young trees of all species, as they preferentially browse meristem tissues and occasionally strip bark off saplings. The other major damage caused by cattle is erosion, particularly in the SMZ where the animals disturb soils as they walk to the water to drink.

3.5.2. Endangered species

Although a biological assessment has not been completed and is not anticipated, endangered species have not been sighted in the area. The purpose of this plan is to establish productive forestry operations on 18.82 acres, and to restore native riparian habitat on 4.45 acres. Endangered plant species will not be used for this restoration effort because their survival rates are not optimal, and the most important objective is to establish robust native species. It is anticipated that endangered animal species may use the riparian zones as corridors, though the total area is likely too limited to serve as residential habitat. Please refer to the full ecological site description prepared by the NRCS for additional details on flora and fauna associations.

4. Anticipated environmental impacts and mitigation measures

4.1. Soil conservation

The proposed project is expected to impact soils solely in a positive way. A century of sugar cultivation by various companies, and two decades of cattle grazing thereafter, has left the parcel with highly compacted soils, a nearly totally alien plant species assemblage, and significant erosion issues due to cattle actively grazing within SMZ. Proposed management actions will improve soils in several ways. First, site preparation in the abandoned pasture areas for hardwood plantings will reverse compaction that occurred during the two decades of grazing. Second, established trees will improve soil retention because their root systems are more extensive than alien grasses, and because cattle will no longer be present in the planted areas. Third, establishment procedures will maintain grass cover in areas between tree rows to stabilize soils while trees are in the juvenile phase; trees will also be mulched, potentially with material derived from invasive species removal in the SMZ, to further protect soils from erosion. Moreover, both native restoration plantings and hardwood trees will be fertilized with formulas appropriate for their respective areas. Native plantings will be fertilized with controlled-release compounds to eliminate risk of eutrophication in the adjacent streams, while nitrogen, phosphorus, and potassium addition to soils for timber plantings will improve overall nutrient balance in this degraded

landscape. College of Tropical Agriculture and Human Resources (CTAHR) fertilization guidelines will be consulted. Please refer to the full Forest Management Plan for further details.

4.2. Water quality

4.2.1. Erosion mitigation

Water quality in the Waiaʻama Stream is currently being negatively impacted by cattle grazing immediately adjacent to the stream. Cattle walk from the pasture to the stream, causing severe erosion along stream banks and continuous input of silt and fecal matter to the aquatic ecosystem. The proposed project will eliminate cattle from the landscape, both stopping SMZ erosion as well as improving water quality and purity. The cattle will be fenced from stream access. In the timber plantings, tree cover will further retain soils such that makai reaches of both Waiaʻama Stream and Ālia stream will experience reduced sedimentation. To reduce erosion, so as to maintain or improve water quality during the site preparation related to the restoration activity, the roots of the cut trees will be left in place. This will stabilize the soil on the steam bank while the root systems of the newly planted native species take hold and replace the non-natives.

4.2.2. Restoration activities

The current density of *P. cattleianum* cover in many sections of the riparian zone is extreme. Following cut stump treatment, debris would be assembled into linear piles (windrows) along contour, providing at once some measure of erosion control and defining the restoration planting beds. In extremely steep areas, killing the current cover and leaving it in place is acceptable—roots of the dead trees will stabilize the steep banks of the Waiaʻama Stream, and will prevent immediate re-colonization. These areas can be occupied over the long term with uluhe fern. Certain herbicide agents must be avoided due to their toxicity to aquatic organisms either in fresh or salt water. Substantial restoration work next to the Waiaʻama Stream will require the use of herbicides to eliminate strawberry guava and other plants, but the particular chemical and dose selected must be safe for use near streams. For example, the chemical triclopyr is not labeled for use where it may contaminate water systems, while the chemical aminopyralid is so labeled. In areas with relatively shallow slopes less than 50%, which is approximately the upper limit where crews can realistically work without highly specialized equipment, invasive tree cover will be controlled using a **cut stump treatment**. In this approach, trees are severed at the base using either a blade or a chainsaw; herbicides are then immediately applied to the exposed vascular tissue. To prepare for planting native tree species, further management of woody debris will be required.

4.3. Impacts on biological resources

Proposed management activities, including restoration and reforestation of degraded SMZ (4.4 acres) and replacement of alien grasses on degraded pasture land by high value hardwood trees (18.8 acres) will yield positive benefits for the land in terms of biodiversity, erosion control, animal habitat, and aesthetics. In SMZ, the vast majority of extant plants are non-natives, principally strawberry guava and ginger. These pernicious invasive species will be replaced by native trees (ʻōhiʻa, pilo, lama) and ferns (hapuʻu, uluhe). Pasture areas of both TMK are currently occupied by alien grasses, which serve no positive purpose for native bird or bat habitat. In contrast, the proposed high-value timber plantings will drastically improve habitat for both groups. Although timber harvesting is not covered in the scope of

this EA or FMP (since no CSG is sought for that activity), harvesting would occur on a selection basis (uneven aged management), which conforms to SoH BMP and would maintain tree cover on the land.

Many of the high value hardwood species proposed for this project rank between 1 and 6 on the University of Hawai'i weed risk assessment scale. These risk values suggest limited potential for invasiveness, and three factors further neutralize this threat. First, the project area is completely surrounded by non-native ecosystems that contain species with far higher weed risk values—these areas act as a containment buffer. Second, the weed risk values 1 – 6 are minimal compared with the species that this project replaces (e.g. strawberry guava (WRA 18) or tropical ash (WRA 11)). Third, the land management prescription calls for aggressive brush control in the hardwood plantings; although this prescription targets primarily species that are truly weeds, it would also address any regeneration of the timber species.

4.4. Access

Significant access infrastructure exists on the property. A road constructed by Hāmākua Sugar Company bisects the property, and a concrete box culvert constructed in 1925 allows easy crossing of the drainage in the Northern parcel. Some access improvement will need to occur, chiefly removing organic debris from the existing road bed. All access improvements will be conducted within the confines of the existing road alignment following the SoH BMP. Maintenance to the culvert appears to be unnecessary at this juncture, although the structure should be monitored for deterioration, particularly spalling of the concrete due to corrosion of steel reinforcements. The main access road will provide operational access during the planting and maintenance phases of the project, as well as serving as the routine access for the landowner. The road is passable by heavy equipment for site preparation as well as ATV and tractor traffic for intermediate maintenance. Ultimately, harvesting equipment would also access the site through this point. Portions of the access road are in ideal condition, with a gravel base and a capped and crowned construction. Numerous sections have been covered by organic debris, however. Access improvement activities will primarily involve removing organic matter from the existing road, and the final condition of the access will conform to road construction BMP.

4.5. Feral ungulate management

The Northern boundary of the property is effectively fenced with barbed wire, but the Eastern boundary is only partially fenced, and is unfenced at the culvert. The Waia'ama Stream acts as a partial natural fence, with the waterfall and steep banks preventing cows from escaping to or entering from the State parcel to the South. The mauka (West) boundary of both parcels is unfenced, however; and cattle and feral pig access must be restricted before planting can begin. **Hunting and trapping will also be employed to control ungulates if necessary.** Fencing will be needed to protect both the restored native forest and the new hardwood plantings primarily from cattle, although the mauka hog-wire fence will also restrict feral pig incursions. Improvements should be made to existing North fence to also restrict pig access; fencing shallow portions adjacent to the Waia'ama Stream is also advised in order to completely enclose the planting area. Fence material will be 4' hog-wire with a barbed skirt to prevent undermining. Fences will need periodic inspection for integrity, and will be repaired as needed every 6 months while the seedlings are young (to year 2), and annually thereafter.

4.6. Impacts on cultural resources

4.6.1. Cultural and historical resources

Just as the century of sugar cultivation and two decades of intensive pasture use have obliterated native ecosystems and resulted in an impoverished flora and fauna across the project area, cultural, archaeological, and historical resources have similarly been erased. Consequently, no negative impacts to historical or archaeological resources are anticipated. The only nominally historical element present on the property is the box culvert from ca. 1925; this feature would be improved and maintained in conjunction with the project, although not using FSP or SoH funding and therefore irrelevant to this EA.

4.6.2. Social issues

The chief social issues involved with forestry projects tend to be (1) aesthetic impacts (trees blocking views) and (2) noise associated with establishment and / or harvesting. First, this project holds zero potential for aesthetic impacts because there are no neighbors at higher elevations and therefore no views to be blocked. Second, establishment activities for this project will involve machinery comparable to that which was in use for decades during sugar cultivation, and similar to machinery currently used in agricultural production on adjacent parcels, translating to minimal impact on neighboring landowners. Finally, harvesting activities are approximately 45 years distant, and since these are not an element of the FMP, should not be considered during review of this EA.

5. Alternatives to proposed management

5.1. No alternative management

The primary alternative to the proposed management is an absence of management. Both parcels are owned outright by KOL, which does not entertain plan for management scenarios other than the FMP under consideration in this EA. Therefore, if the actions proposed here were not undertaken, no management would occur on the property. In an absence of active land management, both pasture areas and SMZ would be rapidly colonized by aggressive invasive plant species, increasing the presence of these unwanted plants as well as the feral ungulates that live in such plant communities. Habitat for native birds and for the Hawaiian bat cannot be regenerated adequately in stands of strawberry guava, which is the primary species that would colonize this land. Overall, the option of no alternative management would yield a landscape in even worse condition than the current pasture cover. In contrast, the proposed action will improve native species biodiversity in SMZ, and improve native fauna habitat in the high-value timber planting areas.

5.2. Alternative agricultural management

Although KOL has no plans to implement alternative agricultural management options, it should be emphasized that these alternatives are also less desirable—from a conservation perspective—than the proposed actions. The two real alternative agriculture options are (1) cultivation of annual row crops and (2) grazing. Regarding (1), repeated tilling of the soil, especially in areas such as Pepeekeo mauka with its high rainfall, leads to significant soil erosion, runoff, siltation, and loss of soil fertility. The proposed management would avoid all of these negative consequences. Regarding (2), grazing is

responsible for soil compaction in pasture areas and severe erosion in SMZ. Forestry projects avoid both of these outcomes, with superior results for ecosystem health, conservation, biodiversity, habitat, etc.

6. Determination

Natural and cultural resource enhancement

The proposed action would replace invasive species with (1) native species in SMZ and (2) high-value hardwood species in degraded pasture areas. This improves natural resources in terms of biodiversity, habitat, and forest cover. This project improves cultural resources by expanding the area on Hawaii Island dedicated to native forest preservation.

Beneficial environmental use

All proposed forestry activities will be consistent with State of Hawaii Best Management Practices. In contrast, current land use (pasture, annual agricultural) is antithetical to forestry BMP; the proposed project therefore replaces a detrimental environmental use with a positive one.

Enhancement of environmental quality

The proposed project is consistent with HRS §344, regarding the policy that projects seeking funding from the SoH, in this case as a CSG, will not conflict with long-term goals of the State environmental policies or guidelines. Moreover, the FMP for which this EA is relevant has been approved by DLNR DOFAW FSP, and is therefore in accord with the FSP guidelines (**Appendix A**).

Cumulative adverse effects

This project will result in no cumulative adverse effects.

Rare, threatened, or endangered species

The parcels involved with this FMP and this EA currently contain virtually no native Hawaiian plants of any type, and support no native fauna. The SMZ restoration elements of this project will restore native Hawaiian plant species along important riparian habitat corridors, thus improving representation of important common Hawaiian tree species as well as providing potential habitat for native fauna.

Economic outcomes

The proposed management actions will involve contracting with local forestry management entities, including foresters, nursery owners, machine operators, forest technicians, and forest laborers. Completing this project will thus yield a net positive economic result for the local community during the establishment and maintenance phases of both the timber planting and the native forest restoration.

Public health outcomes

There are no public health concerns associated with the proposed project.

Secondary outcomes

Not applicable.

Energy consumption

This project consumes no municipal energy, as it features no powered infrastructure.

Aesthetic consequences

Because this project is located mauka from all residential neighbors, the growth of trees can have no negative aesthetic impact.

Overall determination

Anticipated Finding of No Significant Impact.

7. Appendix

State of Hawaii
Forest Stewardship Program Handbook

Department of Land and Natural Resources
Division of Forestry and Wildlife (DOFAW)
1151 Punchbowl Street, Room 325
Honolulu, Hawaii 96813
(808) 587-0160
http://hawaii.gov/dlnr/dofaw/forestry/fsp

January 2013

Table of Contents

Appendices:

State Contacts:

Forest Stewardship Program Coordinator
DOFAW Cooperative Resource Management Forester
1151 Punchbowl Street, Room 325, Honolulu, HI 96813
Phone: 808-587-0166

State Service Foresters
DOFAW Branch Offices:

Hawaii Island	**Maui County**	**Kauai**	**Oahu**
19 E. Kawili St.	54 South High St.	3060 Eiwa St.	2135 Makiki Hts. Dr.
Hilo, HI 96720	Wailuku, HI 96793	Lihue, HI 96766	Honolulu, HI 96822
808-974-4221	808-984-8100	808-274-3433	808-973-9778

State Tree Nursery
66-1220A Lalamilo Rd., Kamuela, HI Phone: 808-887-6061

Forest Stewardship Website:
www.hawaii.gov/dlnr/dofaw/forestry/fsp

Division of Forestry and Wildlife Website:
www.hawaii.gov/dlnr/dofaw

Program Overview

The Hawaii Forest Stewardship Program (FSP) provides technical advice and financial assistance on a cost-share basis to promote the stewardship, enhancement, conservation and restoration of Hawaii's forests. The FSP focuses on the following objectives: forest productivity, native ecosystem health and biodiversity, watershed quality, wildlife habitat and recreation.

The Hawaii Forest Stewardship Program began in 1991 through the passage of Act 327 of the Hawaii State Legislature. The federal U.S. Forest Service Forest Stewardship Program provides administrative support for the state program. The Forest Stewardship Advisory Committee (FSAC) advises the Department of Land and Natural Resources Division of Forestry and Wildlife (DOFAW), who administers the program, on matters regarding the FSP. The Committee reviews FSP project proposals and management plans, and recommends those deserving of funding to the State Forester for program approval. The FSAC members represent federal and state agencies, professional foresters, resource consultants, conservation organizations, non-profit and land trust organizations, and private landowners.

Interested parties are asked to submit a project proposal to DOFAW for review by the FSAC; the FSAC will review proposals and invite those with accepted proposals to write a full Forest Stewardship management plan that must cover a period of at least 10 years. These plans should include all relevant information including any fire first response or timber harvest plans if these practices are desired. For FSP management plans approved by the Committee and the DOFAW State Forester:

1. Management plan development may be partially funded through FSP.
2. Implementation of the proposed or planned conservation practices may be partially funded through FSP and/or USDA-Natural Resource Conservation Service (NRCS) financial assistance programs.

The term of the contract agreement may vary depending on the funding source and scope of the project, but could range from 3 to 30 years. Regardless of the funding program you utilize, it is recommended to develop a long-term forest stewardship plan that includes all practices, timelines, and funding expectations for your project.

Note: that development of Forest Management Plans by NRCS-approved Technical Service Providers may be partially funded by NRCS, and subsequently be eligible for funding under NRCS financial assistance programs.

Applicant Eligibility

To be eligible for FSP, applicants must:

- Own at least 5 contiguous acres of forested or formerly forested land

OR

- Have a lease for a minimum of 10 years on at least 5 contiguous acres of forested or formerly forested land

AND

- Intend to **actively manage at least 5 acres** to enhance forest resource values for *both* private and public benefit

Individuals, joint owners, private groups, associations, lease or license holders, or corporations are eligible. Lands that qualify as Natural Area Reserves are not eligible (see *Appendix F*).

Program Deadlines

The FSP Coordinator accepts proposals and management plans on a continuous basis, which are compiled and reviewed prior to evaluation by the FSAC. The Committee generally meets on a quarterly basis each year; contact the FSP Coordinator for a current schedule. It is highly recommended that the FSP Coordinator is contacted before submitting a proposal and that a draft is submitted before the date of the FSAC meeting to enable preliminary review. By resolving any issues in advance with DOFAW staff, you will increase your chance of success.

Program Procedures for Project Proposals and Management Plan Development

1. Submit a project proposal to the FSP Coordinator. Follow the format on page 16. Project proposals are accepted, rejected, or revisions are requested. Once accepted, an invitation to develop a full management plan is given and the cost-share amount for the development of a plan is negotiated with the FSAC and DOFAW State Forester.

2. Develop and submit a management plan covering at least 10 years of management practices according to the format on page 20. *We recommend you seek the assistance of a professional forester, resource management consultant, or someone with expertise in management plan development unless you are otherwise qualified.* Plans must include a letter from the State Historic Preservation Division verifying there are no archeological, burial or historic sites on the property (see *Appendix A*). Once submitted the Forest Stewardship Advisory Committee may approve, request revisions, ask that additional detail be incorporated into the management plan, or disapprove the plan. Reimbursement development of the management plan based on the negotiated cost-share amount is made upon final approval of the plan by the Forest Stewardship Advisory Committee and the State Forester.

3. Prior to submission of final management plan, arrange a site visit with the FSP Coordinator, DOFAW Service Forester, and/or NRCS Soil Conservationist or designee to verify proposed practices and cost-share estimates.

4. Sharing the cost (cost-share) of Forestry Practices. Approved of a Forest Stewardship management plans are eligible for cost-share assistance for the implementation of practices as detailed in the plan. Eligible cost-share practices are found starting on page 6 and estimated cost-share rates are included in *Appendix B and C*.

5. Submit approved management plan for cost-share assistance for implementation of the management practices. The FSP Coordinator, on your behalf by request, will submit approval documents detailing FSP management plans to the appropriate funding agency. Both the Hawaii Forest Stewardship Program and NRCS financial assistance programs can provide cost-share assistance for approved FSP management practices. Details on both the State Forest Stewardship Program and NRCS financial assistance program funding options are available in *Appendix B and C*.

6. IF NECESSARY – Environmental compliance may be required. Depending on the funding

sources and project scope, an Environmental Assessment may be required to implement your management plan. Archeological surveys may be required where there is strong evidence to suggest the existence of archeological or historic resources. Grubbing and Grading Permits or Soil Conservation Plans may be required for construction related actions. If the project is within the conservation district, a Conservation District Use Permit may be required. If you plan to collect, propagate or plant threatened and endangered species, a permit will be required, contact the State Botanist at (808) 587-0166. (*Appendix A*)

7. Submit documents required to complete a contract with either Hawaii Forest Stewardship Program or NRCS. After management plans are approved, DOFAW or NRCS staff will prepare a contract agreement, which you review and sign. DOFAW or NRCS staff will instruct you on what documents and other compliance is needed to finalize your contract agreement. Some of the required information may include submission of a W-9 Form, federal and state tax clearances, a General Excise Tax Number, and/or other evaluation forms.

8. Submit semi-annual progress reports, invoices, and cost documentation. Templates for reports will be provided once your project contract agreement is approved. DOFAW or NRCS staff will visit your project site to verify practice completion and discuss progress or problems. Information contained in reports may be shared with the public.

Please note for FSP it takes at least 6-12 months from when a proposal is submitted to contract execution. Cost share funds will not be dispersed until the contract is fully executed and initial management practices have been completed and are ready for inspection and reimbursement.

Forest Stewardship Program Management Plans

FSP management plans cover a minimum period of 10 years, but can be longer. Professional services may be required in developing your management plan.

Management Objectives

- Forest Stewardship management plan development
- Growth and management of forests for timber and other forest products
- Native species restoration and/or protection
- Agroforestry (the forestry component only)
- Windbreaks (to protect forestry project areas)
- Fire pre-suppression
- Watershed, riparian, and/or wetland protection and improvement
- Forest recreation enhancement
- Native wildlife habitat enhancement
- Native forest conservation

Orchards, non-tree related agriculture and landscaping are NOT eligible objectives

Management Plan Practices

1. Forest Stewardship Management Plan Development

It is highly recommended that forestry projects have a management plan prior to any practice is implemented. Long term management plans will allow you to state your objectives, identify resource concerns, financially plan for activities, define monitoring protocols, identify where and when practices should be used, among others items. All FSP projects must have an approved management plan before they can be authorized for cost-share assistance. Please use the format detailed in this handbook when developing your plan (found on page 20). DOFAW staff provides applicants with technical expertise during plan development, but will not write the plan for you. A forestry consultant is highly recommended to assist with plan development, especially in regards to fire pre-suppression and first response as well as timber harvest planning.

Revisions/Amendments: Your plan may be revised as necessary to account for changing conditions. Increased costs of business should be built into annual budgets to avoid mid-decade amendments. All amendments are subject to approval by the Forest Stewardship Advisory Committee and the State Forester, and could result in project delays. All non-native species added to your plan or project site must be approved prior to their use.

2. Tree and Shrub Site Preparation

Most planting projects require the reduction or removal of existing vegetation, especially in the case of invasive species management, and/or site preparation to increase seedling survival. Heavy or light equipment or hand-labor may be cost-shared if you:

- Follow elevation contours when using heavy soil-moving equipment.
- Never use equipment in Streamside Management Zones
- Follow Best Management Practices to minimize erosion. See the guide at http://www.state.hi.us/dlnr/dofaw/pubs/BMPs_bestmanagement.pdf

You may need to improve the soil condition for seedling growth or natural regeneration by using tilling and sub-soiling where soil is compacted or where there are hardpans. In some cases, scarification can be used to promote the regeneration of *Acacia koa* where it once existed. Maximum allowable costs can vary depending on the density of existing vegetation, soil conditions, presence of a hardpan, and the steepness of the slope.

Components of Tree and Shrub Site Preparation

A) Tree/Shrub Site Preparation (NRCS practice code 490): Tree/shrub site preparation is the treatment of areas to improve site conditions for establishing trees and/or shrubs. This practice is used to encourage natural regeneration of desirable woody plants and to permit artificial establishment of woody plants.
B) Deep Tillage (324): Performing tillage operations below the normal tillage depth to modify adverse physical or chemical properties of a soil.
C) Woody Residue Treatment (384): Treating woody plant residues created during forestry, agroforestry and horticultural activities to achieve management objectives.

*The NRCS practice codes should be included in your management plan especially if you intent on using a NRCS financial incentive program.

3. Fence

If seedlings and young trees need protection from feral and/or domestic animals, such as pigs, sheep, deer, cattle, horses, goats and humans; fences and other tree protection measures may be necessary. Fence cost-share limits depend on the type of fencing necessary for the site and intended purpose, which should be described in your management plan including specification on type (e.g. electric, barbed wire, cattle proof, etc), height, materials (e.g. wire, posts, gates, etc), and difficultly of installation. Please provide three (3) estimates of costs for all game proof fences, especially if costs are anticipated to exceed the allowed rates identified in *Appendix B* and *C*. Fences MUST be maintained for at least ten (10) years following installation and maintained in a manner that preserves their intended function, such as protecting seedlings from feral or grazing animals.

Components of Fence

A) Fence (382): A constructed barrier to animals or people. This practice facilitates the accomplishment of conservation objectives by providing a means to control movement of animals and people, including vehicles.

4. Nutrient Management

Some project sites may require additional nutrient management in order to ensure successful plantings; we highly recommend having the soil tested prior to augmentation. The University of Hawaii's Agricultural Diagnostic Services Center provides soil, water and tissue testing. See www2.ctahr.hawaii.edu/adsc/downloads/price_list.pdf or http://websoilsurvey.nrcs.usda.gov for more information. Fertilizers and soil amendments may be organic or inorganic. Soil tests and professional recommendation rates for each species are required for cost-share on fertilizers. Soil amendments to improve the structure and fertility of the soil immediately surrounding the seedling root zone can also be cost-shared, including hydrating polymers.

All amendments must be used in accordance with registered uses, directions on labels, and all other applicable federal, state and local policies. Careful consideration should be applied regarding induced deficiencies of nutrients due to excessive nutrient levels and the affects of soil pH on the availability of plant nutrients. Do not apply inorganic fertilizers near to streams or wetlands where polluted runoff might enter water. Fertilizer applications are generally eligible for cost-share assistance for a period of up to four years subsequent to planting seedlings. Generally, the highest cost-share limit is applicable only where soil depletion is extreme and is justified by soil tests and recommendations.

Components

A) Nutrient Management (590): Managing the amount, source, placement, form and timing of the application of plant nutrients and soil amendments.

5. Tree and Shrub Establishment

Depending on the management goals, most projects will require the establishment of trees and/or shrubs. You must consider the current and former plant communities at your site when choosing species. Seedlings should be purchased from local growers who use genetically diverse seeds or stock from as close to your planting location and/or habitat as possible. It is advised to order plant stock well in advance (three to four months for most species) to get the quantity, quality and species that you desire for your project. Use smaller container stock such as dibble tubes, airblock, or root-trainer, as opposed to

larger, potted stock to reduce site preparation and planting costs; however, this may vary depending on the species you select. Seedlings should be in good condition, adequate size and "hardened off" before planting. Seedlings that have been in containers for too long may not be healthy and will not grow as well once planted. A detailed species list is required in the management plan. **Projects that include invasive species will not be funded** unless there is an overriding environmental justification for their use (see General Advice). *Fruit trees are not eligible for cost-share unless the product of interest is for timber purposes.*

Seedlings are usually planted at the beginning of the wet season, and the planting area should be cleared of all weeds and competing vegetation from around newly planted seedlings to an area of at least 3 feet in diameter. Where dibble stock is used, soil is of good structure and there is adequate rainfall, the planting holes only need to be big enough to accommodate the small dibble. Where larger planting stock is used, holes must be large enough to accommodate freely hanging roots, or root balls. Roots should never be bent or crowded. Where long droughts may threaten seedling survival, larger holes can serve as water storage reservoirs, greatly increasing seedling survival rates. Holes dug through sod or untilled ground should be at least 16 inches square. *Do not place the plant so deep into the hole that the stem is buried.* Mix soil amendments or additives with soil before planting holes are filled to improve growing environment and soil water holding capacity. Avoid glazing sides of planting holes with digging tools, especially augers, in wet clay. Plantings for native forest restoration and tree plantations should be carefully and consistently maintained to assure the survival of a majority of the trees planted. Direct seeding or seed scatter are appropriate method and can be used for establishing trees, shrubs and groundcovers.

The NRCS Vegetative Guide provides species recommendations for planting relating to implementation of several management practices at: http://www.plant-materials.nrcs.usda.gov/pubs/hipmstn9761.pdf
These lists are merely recommendations and do not exclude consideration of other species.

NRCS has also developed Ecological Site Descriptions for most of the Island of Hawaii. These are descriptions of different forest types, including detailed native species lists that correlate to specific soil types described in NRCS soil survey data. They are one basis for making native species planting recommendations for specific site. Current Ecological Site Descriptions are available at: http://efotg.nrcs.usda.gov/efotg_locator.aspx?map=HI. Click on the image of Hawaii, then the image of any island, then look in the left-side column and select Section II.

Components

A) Tree/Shrub Establishment (612): Establishing woody plants by planting seedlings or cuttings, direct seeding, or natural regeneration.
B) Riparian Forest Buffer (391): An area predominantly trees and/or shrubs located adjacent to and up-gradient from watercourses or water bodies.
C) Alley Cropping (311): Trees or shrubs are planted in sets of single or multiple rows with agronomic, horticultural crops or forages produced in the alleys between the sets of woody plants that produce additional products.
D) Multi-story Cropping (379): Existing or planted stands of trees or shrubs that are managed as an overstory with an understory of woody and/or non-woody plants that are grown for a variety of products.
E) Silvopasture Establishment (381): An agroforestry application establishing a combination of trees or shrubs and compatible forages on the same acreage.
F) Windbreak/Shelterbelt Establishment (380): Windbreaks or shelterbelts are single or multiple

rows of trees or shrubs in linear configurations.

6. Groundcover Establishment

Many projects may need to establish a temporary or permanent groundcover in order to protect from soil erosion, enhance habitat for wildlife, and/or limited the establishment of invasive species. Groundcover can be temporary or permanent vegetative cover including grasses, sedges, rushes, ferns, legumes, and forbs. Plant species selected should be adapted to the site condition, have physical characteristics to provide adequate protection, as well as appropriate for the duration that they are needed (i.e.: annual or perennial species). Implementation of this practice should be timed in conjunction with other practices as well as weather conditions in order to prevent soil erosion. This practice is also appropriate for use in agroforestry systems.

Components

A) Conservation Cover (327): Establishing and maintaining permanent vegetative cover.This practice may be applied to accomplish one or more of the following: Reduce soil erosion and sedimentation, Improve water quality, Improve air quality, Enhance wildlife habitat and pollinator habitat, Improve soil quality, Manage plant pests.
B) Cover Crop (340): Crops including grasses, legumes and forbs for seasonal cover and other conservation purposes.
C) Riparian Herbaceous Cover (390):Grasses, sedges, rushes, ferns, legumes, and forbs tolerant of intermittent flooding or saturated soils, established or managed as the dominant vegetation in the transitional zone between upland and aquatic habitats.

7. Irrigation

Irrigation systems should be used only in areas where rainfall is not dependable to enhance seedling survival and growth during early development. Irrigation should not to be used to maintain trees as they become mature. Use mulch where feasible to help maintain soil moisture (see next section), and where feasible use drip irrigation. Cost-share assistance is available for system installation only; system maintenance and repairs are the responsibility of the applicant. Irrigation is only eligible for cost-share assistance for a period of up to four years following the seedling planting date. Allowable cost-share rates are for drip irrigation only. For catchment systems and ponds please provide three quotes for allowable cost-share rates. Irrigation systems should be maintained until the plants can survive on their own through a normal dry season. Please see a free publication at www.ctahr.hawaii.edu/oc/freepubs/ for assistance in designing irrigation systems.

Components

A) Irrigation Pipeline (430): A pipeline and appurtenances installed to convey water for storage or application, as part of an irrigation water system.
B) Irrigation Reservoir (436): An irrigation water storage structure made by constructing a dam, embankment, pit, or tank.
C) Irrigation Water Management (449): The process of determining and controlling the volume, frequency and application rate of irrigation water in a planned, efficient manner.
D) Irrigation System Sprinkler (442): An irrigation system in which all necessary equipment and facilities are installed for efficiently applying water by means of nozzles operated under pressure.

8. Mulching

Use organic mulch at least 2 inches thick where feasible to help control weeds after planting. Keep mulch away from plant stems where it can cause rot. Mulch consists of plant residues or other suitable manufactured materials. More information about mulching as a practice can be found here: http://miami-dade.ifas.ufl.edu/pdfs/fyn/mulch-practices.PDF

Components

A) Mulching (484): Applying plant residues or other suitable materials produced off site, to the land surface.

9. Weed Control

Ongoing weed control and management are required for many projects, especially were invasive species are present. Establishment and maintenance of non-invasive ground covers (Groundcover Establishment) and native understory plants can assist with preventing establishment and re-establishment of unwanted vegetation, but additional chemical or mechanical methods may be needed to suppress weeds. Use higher planting densities and/or ground covers to shade out weeds, and eliminate or control weeds with herbicides, mechanically or by hand. Use control measures designed specifically for the particular weed species and minimize adverse environmental impacts when applying herbicides (Don't spray when it's windy, use the lowest rate of the least toxic alternative possible). Apply chemicals in accordance with registered uses, directions on labels, and all other applicable federal, state and local policies. Buffer zones surrounding planting areas are also eligible for weed control practices to prevent the spread of weeds into the planted area. Weed control should continue into the post 10-year management plan period as ongoing maintenance to assure tree survival and normal growth.

Components

A) Brush Management (314): The management or removal of woody (non-herbaceous or succulent) plants including those that are invasive and noxious.

B) Herbaceous Weed Control (315): The removal or control of herbaceous weeds including invasive, noxious and prohibited plants.

10. Fuel Break

Fire is a major threat to our natural resources and in some cases significantly increases the spread of non-native species. Fire can also result in forest fragments and in some cases create a fire cycle that is otherwise uncommon to the Hawaiian Islands. Projects in high fire threat areas must be protected from fire, typically via maintained fuel breaks. Other methods for fire protection or pre-suppression will be considered on a site specific basis. Fuel breaks can be maintained through chemical methods and mechanical (mowing) methods or by use of managed grazing animals. All projects should include a fire response plan which should include water availability, first responders, and contact information for those involved in fire suppression. Please include information on your projects fire first response plan in your management plan. Sites that are prone to fire danger or are in need of fire prevention or mitigation measures may be eligible for cost-shared rates.

Components

A) Fuelbreak (383): The manipulation of species composition, stand structure and stocking by cutting or killing selected trees and understory vegetation.

11. Windbreak

Windbreaks can significantly reduce the negative effects associated with strong wind, including topsoil erosion, broken branches, salt spray, and growth inhabitation, among other cumulative damages. Strong winds can also reduce the success of your project by sucking moisture from the soil and the plants. Windbreaks generally consist of one or more rows of trees and shrubs planted to protect an area from prevailing winds, and to be most effective they should be perpendicular to the wind direction. More information about windbreaks use and advantages can be found here:
http://www.ctahr.hawaii.edu/ctahr2001/CTAHRInAction/Jul_02/windbreaks.html

Components

A) Windbreak/Shelterbelt (380): Windbreaks or shelterbelts are single or multiple rows of trees or shrubs in linear configurations.

12. Special Areas Practices

Highly erodible, very steep and/or inaccessible sites may require more intensive methods to establish permanent vegetation, including trees, shrubs, ground covers, and grasses. In addition to the practices listed above, the following can be employed in these areas:

- Erosion control matting and/or other erosion control materials such as coir logs or rocks.
- Labor-intensive methods of hand-clearing undesirable vegetation.
- Terracing, water diversions, or other grading. *Additional permits may be required.*
- Establishment of more expensive plants in larger containers.
- Other materials and/or methods as necessary.

The applicant must obtain 3 quotes for the proposed work and materials, and consult with the FSP Coordinator to determine the allowable cost-share. Due to limited funds, this option may not always be available.

Components

A) Critical Area Planting (342): For Highly Erodible Lands (HEL) or Steep areas - Establishing permanent vegetation on sites that have, or are expected to have, high erosion rates, and on sites that have physical, chemical or biological conditions that prevent the establishment of vegetation with normal practices.
B) Stream Habitat Improvement and Management (395): Maintain, improve or restore physical, chemical and biological functions of a stream, and its associated riparian zone, necessary for meeting the life history requirements of desired aquatic species.
C) Stream Crossing (578): A stabilized area or structure constructed across a stream to provide a travel way for people, livestock, equipment, or vehicles.
D) Streambank and Shoreline Protection (580): Treatment(s) used to stabilize and protect banks of streams or constructed channels, and shorelines of lakes, reservoirs, or estuaries.
E) Other Project Needs: The FSAC will consider use of other practices needed to protect sensitive areas or that will ensure successful plantings(such as constructed windbreaks). Please consult the FSP Coordinator prior to submission of the management plan.

13. Trail and Road Construction

Cost-sharing is available for trails in forest areas to enhance their recreational value, and to provide for public access, educational opportunities, and fire protection. Do not eliminate key trees that have scenic value, provide shade, reduce erosion and runoff, provide unique habitat for wildlife, or that add aesthetic value in the area - this includes tree snags. Develop trail grades suited for the intended purposes,

consider the topography, and avoid exceeding 10 percent slopes. Wherever possible, trail width should remain between 2 and 4 feet. Cut and fill slopes must be stable and include provisions for erosion control. Re-vegetate as soon as possible following trail construction. Design bridges, crossings, and elevated trails with professional assistance. Try to place directional and warning signs, handrails and culverts as dictated by the limitations of site. Include provisions for maintaining all wearing surfaces, signs and drainage structures for ten years following installation.

Components

A) Trail Construction: Work involved with creating and/or maintaining trails to access work sites or for public recreational use.
B) Water Crossings: Improved features for crossing streams or other water bodies to access work sites or for public recreation.
C) Signs: Design, purchase and installation of signs to identify important features of the project to provide public information or to denote project area for safety concerns.
D) Forest Trails and Landings (655): Construction of trails and lands for timber harvest activities.

14. Forest Stand Improvement

Where stands of trees are overstocked or over topped by less desirable trees, thinning can increase the growth, health and the future value of desired trees. Consider which species will be favored after thinning and if weeds will take over with more sunlight available. Choose cull (non desirable) trees with the assistance of a professional forester and plan for slash (biomass waste) disposal after thinning. Determine the best season and method for thinning. This practice can also be used to remove infected and/or host plant species to limit the spread of disease and pests.

Timber harvest should be conducted in accordance to an approved timber harvest plan AND in accordance to mandatory permits such as CDUP, EA, etc. (*Appendix A*). Timber cruises and inventories are a necessary part of any timber harvest plan. It is very important to consider the extraction method in the plan, as this could be very costly and/or inflict serious ecosystem damage. It is important to consult a professional when developing a timber harvest plan. See *Appendix B* for the timber harvest payback provision.

Components

A) Forest Stand Improvement (666): The manipulation of species composition, stand structure and stocking by cutting or killing selected trees and understory vegetation.

15. Tree and Shrub Pruning

Pruning is a practice that alters the form and growth of a plant to improve the grow form of the selected species as well as for preventative maintenance. Removal of dead or drying branches injured by disease, severe insect infestation, storm or other adverse damage may be used to prevent unwanted growth form during early years of development. Pruning may also be required to maintain windbreaks to ensure desired tree form. Pruning often promotes better form and health by increasing light penetration and air movement.

Components:

a) Tree and Shrub Pruning (660): The removal of all or part of selected branches, leaders or roots from trees and shrubs.

16. Forest Health and Protection

Forest health practices may be utilized to improve growing conditions for plants, prevent the spread or introduction of invasive or weed species, improve wildlife habitat, among other reason. Projects may want to consider the use of biological controls; alternative methods for reducing invasive animal species population species, such as rats, mice, slugs, snails, cats, feral ungulates, etc.; and/or other pest prevention activities.

Components

A) Integrated Pest Management (595): A site-specific combination of pest prevention, pest avoidance, pest monitoring, and pest suppression strategies.
B) Animal Control: Reduction and/or elimination of harmful non-native animals from a project area. Feral ungulates, cats, rats, mice and mongoose as well as non-native snails and slug control can be incorporated into management practices, as appropriate.
C) Other Tree Protection: Tree tubes, shade clothes, and other animal barriers may be considered.

The applicant must obtain 3 quotes for the proposed work and materials, and consult with the FSP Coordinator to determine the allowable cost-share. Due to limited funds, this option may not always be available.

19. Monitoring and Maintenance

All applicants are asked to include a monitoring plan for their proposed project. The monitoring plan should detail the frequency of monitoring for the associated practice and describe what will be recorded in monitoring reports (i.e.: seedling survivorship, weed control and present, etc). This information will help you determine if your project is successful as well as guide the need for practice modification in the future.

Under FSP, participants are expected to maintain cost-shared improvements for at least ten years following installation or for the life of the practice. "Maintain" means the improvements will not be willfully removed or destroyed and routine maintenance will assure that under normal conditions the improvements will serve the intended purpose. Details are given in each management practice description above and below.

Components

A) Access Control (472): The temporary or permanent exclusion of animals, people, vehicles, and/or equipment from an area.
B) Upland Wildlife Habitat Management (645): Provide and manage upland habitats and connectivity within the landscape for wildlife.

Cost-share and Allowable Rates

Implementation of conservation practices under approved Forest Stewardship management plans are eligible for cost-share assistance for your planned practice expenses under the Hawaii Forest Stewardship Program and NRCS financial assistance programs. Cost-share under assistance programs must be within the allowable rates and is generally on a reimbursement basis. You can include "in-kind" services (non-cash) such as labor costs, your own materials, and the use of your own equipment as part of your cost-share contribution. Allowed cost-share rates and additional information about these

programs is included in *Appendix B and C*.

General Advice

Invasive Species
Projects that include invasive species will not be funded unless there is an overriding environmental justification for their use. The following procedures will be used to judge whether a non-native species is considered invasive and/or approved or disapproved:

1. No species on the state 'Noxious Weed List' will be funded. See Page 11 of the state rules: www.hawaiiag.org/hdoa/adminrules/AR-68.pdf
2. Non-native species proposed for planting must be listed in FSP management plans or submitted as revisions of previously approved management plans. If the landowner is aware that the species may be considered invasive the plan should include a justification of the use of the species. New management plans and associated species lists are always reviewed by FSAC.
3. You can search for the invasive status of particular species at the Weed Risk Assessment website: https://sites.google.com/site/weedriskassessment/home
4. DOFAW FSP staff will gather information and recommendations about non-native species from DOFAW Branch staff and the Weed Risk Assessment scores; if there is no clear consensus, further information will be sought from invasive species experts.
5. For new non-native species added to revised management plans: If the information in step #4 clearly indicates that the species is not invasive, it will be approved by FSP staff without waiting for a FSAC meeting. If the information in step #3 indicates that the species may be invasive, the species may not be approved until reviewed by the FSP Committee.
6. If the FSAC disagrees about whether to consider the species, the final decision will be made by the DOFAW Invasive Species Coordinator.

These guidelines follow Federal Executive Order #13112, quoted below. In applying the Executive Order to the Hawaii FSP, (a) successful justifications for the use of invasive species will emphasize environmental benefits rather than economic benefits, and (b) new introductions of potentially invasive species carry a high risk of harm and will not be funded. Generally speaking, if there is a lack of information or clear understanding about how the species has or will affect Hawaiian ecosystems, the species in question will not be funded.

> Federal Executive Order #13112 directs that [Federal] agencies "not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions."

Compliance
It is the responsibility of the applicant and/or consultant to complete all required environmental reviews, permits, and other compliance documents for their project. Any required permits and other environmental compliance must be approved prior and included with the plan when submitted for cost-share assistance under either the Hawaii Forest Stewardship Program or NRCS financial assistance program (environmental compliance requirements may vary between the two agencies). Descriptions of some required review and permits documents are included in *Appendix A*.

Best Management Practices (BMP's)
All FSP participants must adhere to current DOFAW **Best Management Practices** that are relevant to the project: www.state.hi.us/dlnr/dofaw/pubs/BMPs_bestmanagement.pdf. It is acceptable and encouraged to 'think outside of the box' and to utilize new technologies, as long as prior approval is gained by the FSAC and/or DOFAW State Forester.

Distribution and use of approved Forest Stewardship Management Plans:
The following information will be available as required by the Freedom of Information Act: name, address, project location, and funding provided. One of the objectives of the FSP is to generate useful information for landowners throughout Hawaii who may be considering forest management as a land use alternative. During the course of the project, you will be asked to share your experiences and knowledge, and to contribute to the development of data and be informational sources for others.

Once you are enrolled in the FSP your approved management plan will be made available for copy and distribution to the general public upon request. You are thus advised to delete any information that you consider to be proprietary, prior to submitting the management plan to the Forest Stewardship Advisory Committee. You can present relevant proprietary information to the Committee separate from the management plan. As required by the Freedom of Information Act, your name, project location, and funding is available, but will not be actively publicized. Although approved Forest Stewardship Management Plans are available for distribution to the general public, they should be used by potential applicants for informational purposes only. Any management plans that appear to plagiarize previously approved plans will not be accepted.

Project Proposal Form – Step One

In order to receive cost-share assistance for your project, you must submit a project proposal for review by the Forest Stewardship Advisory Committee. If the Committee approves this proposal, you will be invited to develop a full management plan. Upon completion and approval of your management plan, funding possibilities include (1) the Hawaii Forest Stewardship Program (FSP) for long-term management, eligible for 50% cost-share assistance; and/or (2) various USDA Natural Resource Conservation Service (NRCS) or Farm Service Agency (FSA) financial and technical assistance programs for plan implementation, eligible at 50% to 75% cost-share assistance (dependent on program). **Note**: An approved Forest Stewardship management plan is a valid proxy for an approved NRCS conservation plan. Retroactive cost-share (partial reimbursement) for Forest Stewardship management plan development is available for all management plans if and when they are approved. Project proposals should specify if the applicant is interested in funding support from the Hawaii Forest Stewardship Program, USDA (indicate program(s) if known), a combination of both, or for some other purpose.

Please submit the project proposal via e-mail to the Cooperative Resource Management Forester (contract information available at www.hawaii.gov/dlnr/dofaw/fsp) or by compact disk to DOFAW Forest Stewardship Program, 1151 Punchbowl Street Room 325, Honolulu, HI 96813.

[Start of Proposal Form]

1. Applicant and Property Information
Applicant Name:
Mailing Address, Email, Phone, Fax:
Landowner name:
Lease/License holder name:
Effective date of lease and lease term:
Address and Tax Map Key number(s) of project location:
State Land Use and County Zone designation:
Farm Service Agency Farm No. and Tract No. (if you already have one):
Driving directions from the nearest highway:
Property acreage:
Proposed acres in stewardship management area:
Ethnicity (optional):

2. Project Vision and Goals - Please describe your long-term vision and goals for the property and project (at least a paragraph of description).

3. Description of the project property or the land area to be managed
Existing flora/vegetation (native, non-native and/or invasive species):
Existing fauna/wildlife: (native, non-native and/or invasive species – birds, rats, cats, mongoose, frogs, ungulates, etc):
General elevation:
Slope:
Are gulches or any waterways present?

4. Land Use for the entire property (Place an "X" under all that apply):

	Pasture	Crop land	Sugar cane	Range land	Forest grazed	Forest non-grazed	Other - please describe
Historic							
Current							
Proposed							

5. Natural Resource Concerns - Please check all resource concerns that apply to the project:

□ Noxious and invasive species
□ Organic material depletion
□ Plants not adapted or suited to site
□ Threatened and endangered species
□ Inadequate cover for wildlife
□ Inadequate shelter for domestic animals
□ Harmful temperatures of surface water
□ Water quality, excess sediment
□ Hydrologic Cycle, capture and storage of rainfall
□ Soil erosion
□ Soil compaction
□ Plant productivity, health, or vigor
□ Wildlife habitat fragmentation
□ Inadequate food for wildlife
□ Undesirable air movement
□ Adverse air temperature
□ Insufficient flow in watercourses
□ Other: _____

A complete list of resource concerns and descriptions are available at:
http://efotg.nrcs.usda.gov/references/public/HI/quality_criteria_table_final_april_25_2005.pdf

6. Forest management objectives - Please check all objectives that apply to the project:

□ Forest Stewardship management plan development
□ Growth and management of native and non-native forests for timber and/or forest products
□ Native species restoration
□ Wildlife habitat improvement (list wildlife)
□ Agroforestry systems (forestry component)
□ Windbreaks (to protect forestry project areas)
□ Watershed, riparian, and/or wetland protection and improvement
□ Forest recreation enhancement and/or education and community outreach
□ Fire prevention
□ Carbon storage or sequestration and/or biomass production
□ Silvopastoral systems
□ Other _____

Please describe in a short paragraph how your project will address the above checked natural resource concerns and incorporate the forest management objectives checked above.

7. Proposed practices - Please check all practices that apply to your project:

□ Management Plan (required)
□ Fence
□ Tree and Shrub Establishment
□ Irrigation
□ Tree and Shrub Site Preparation
□ Nutrient Management
□ Ground Cover Establishment
□ Mulching

□ Weed Control
□ Windbreak
□ Trail Construction
□ Tree and Shrub Pruning
□ Monitoring and Maintenance
□ Fuelbreak
□ Special Areas Practice
□ Forest Stand Improvement
□ Forest Health and Protection

8. Maps

1) Please attach a topographic map showing the area. Use topozone.com, googlemap.com and/or other appropriate maps (soils, roads, etc) to identify the location of the proposed project.
2) Provide a map/sketch of your project area(s) and where specific management practices will be applied.

9. Vegetation Selection - Attach a list of species you propose to plant. Please see the Forest Stewardship Program Handbook for information concerning invasive species. If containerized seedlings or vegetative propagation methods are proposed as a source of planting stock, please describe. If soil scarification is proposed as a method to stimulate natural regeneration, please describe.

10. Public benefit - Please check all public benefits that apply to the project:

□ Economic diversification/employment (commercial production of a significant scale)
□ Native ecosystem and biodiversity restoration
□ Watershed improvement/protection
□ Native wildlife habitat enhancement
□ Educational, recreational or ecotourism opportunities
□ Carbon sequestration and storage, and/or biofuel production
□ Other ecosystem services: _____

11. Organizations that will be involved in the project

Briefly list and describe partnerships with other resource management agencies and organizations. If you plan on using grants or cost-sharing from other programs as a source for your part of the required match, please describe the source and amount of funding expected.

12. Estimated costs

This table can help you get a rough idea of how much your project will cost. Please see *Appendix B and C* for the Hawaii Forest Stewardship Program and NRCS financial assistance programs practice cost-share lists for guidance on allowed cost-share rates under each program.

Example: If you prepare 10 acres for planting (site prep) at a cost of $800/acre (done only once per acre) then the total practice cost will be $8,000. The Hawaii Forest Stewardship Program will pay $400/acre (50% of the actual cost, within the cost-share limits) or a total of $4,000. You will be responsible for the matching $400/acre of the practice which can be in-kind match of labor and/or equipment or actual cash you contribute to install the management practice (could be your own money or other funding sources).

Table 1: Example of Estimated Costs Breakdown

Practice Component	**Acres**	**Cost/Acre (Or Mgmt Plan)**	**Frequency or # of acres**	**Actual Total Cost**	**Estimated Landowner Cost-share**	**Estimated Program Cost-share**
Management Plan*			1 plan*		Negotiable*	Negotiable*
Tree and Shrub Site Preparation						
Fence						
Nutrient Management						
Tree and Shrub Establishment						
Groundcover Establishment						
Irrigation						
Mulching						
Weed Control						
Fuel break						
Windbreak						
Special Areas Practice					Negotiable	Negotiable
Trail Construction						
Forest Stand Improvement						
Tree and Shrub Pruning						
Forest Health and Protection						
Monitoring and Maintenance						
TOTALS						

A Forest Stewardship Management Plan should address individual landowner objectives while meeting professional resource management standards.

*Project proposals must attach at least three quotes for the development of a Forest Stewardship management plan to be eligible for cost-share assistance on the development of the plan. If you are unable to obtain quotes from three professionals, please contact the Cooperative Resource Management Forester.

13. Other Information

You may add any photos or other details to this application you think will help us understand the project. Provided more information about your project will increase your chances for approval by the Forest Stewardship Advisory Committee.

[End of Proposal Form]

Upon submission and review of your project proposal, the Forest Stewardship Program will either:

(1) invite you to complete a full management plan,

(2) ask you to provide more information for a secondary review, or

(3) your request for management plan assistance may be declined.

Forest Stewardship Management Plan Template – Step Two

If the project proposal is accepted, you will develop a detailed and comprehensive Forest Stewardship Management Plan, which may require the services of a professional forester or resource management consultant. The management plan must meet standards set forth in national and state Forest Stewardship Program guidelines and follow the management plan template format below.

Management Plan development costs generally range from $1,500 to $10,000 depending on plan complexity. The cost-share amount provided by the FSP is negotiated after the project proposal is accepted, but many not exceed 50 percent of the total cost to develop the management plan. The cost-share for the management plan is payable upon receipt of the final management plan, approved by the Forest Stewardship Advisory Committee and the State Forester, and a receipt from the consultant's invoice has been received. **All cost-share funds are paid on a reimbursement basis.** Management plans should specify if the applicant is interested seeking funding support for management plan implementation from the State of Hawaii Forest Stewardship Program or other federal landowner assistance program, such as NRCS EQIP (*Appendix B and C*) .

[Start of Management Plan Template]

I. Cover Sheet

- Applicant information (same as project proposal)
  Name, address, email, phone and fax number
- Property information (same as project proposal)
  Landowner name:
  Lease/License holder name:
  Tax Map Key number(s):
  State and County land use district or (zone) designation:
  Property acreage:
  Farm Service Agency Tract Number (if you already have one):
  Acres of stewardship management area:
  Approximate elevation:
  Slope:
  Perennial or intermittent stream courses:
- Consultant's name, title, company, address, email, fax and phone number
- Date the plan was completed (or revised)

II. Signature Page (*Appendix D*) with signatures of the applicant, consultant, approval date by Forest Stewardship Advisory Committee, and State Forester.

III. Introduction

- Vision and long-term goals of the project
- Description of the property
- Overview of the project specific management objectives (can include topics identified from the project proposal). Please provide further clarification or detail on the specific goals or objectives of the project.
- Detailed maps showing the location and attributes of the project

- Brief history of land uses and a description of present conditions

IV. Land and Resource Description

Describe the existing condition of the land and natural resources found within or surrounding, as applicable to the project area. Please identify the resource concern (can include topics identified from the project proposal) such as:

- Existing vegetation/forest cover types
- Existing forest health and function, including any invasive species, chronic disease, insect, rodent and/or fire threats
- Soils and their condition
- General slope and aspect
- Water resources and their condition
- Timber resources
- Wetland resources
- Significant historic and cultural resources. State whether an archeological survey has been done. If so, provide a summary. (*Appendix A*)
- Existing wildlife – please provide a list
- Threatened and endangered species existing on property
- Existing recreational and aesthetic values
- Infrastructure and access conditions

V. Management Objectives and Practices

Describe the management objectives and practices of the project, and specifically how you intend to implement and maintain outcomes for at least 10 years after installation of the practices in order to achieve your desired forest resource management objectives. Management plans should clearly describe each practice and how it will address the associated natural resource concerns. Plans should also define management units/forest stands and/or acreages for each treatment/practice (subunits may be used if necessary).

Forest management plan development and the following conservation practices may be eligible for cost-share. Please provide a brief description of the purpose(s), quantity and type or approach for each selected practice and describe what steps you will take to conserve, protect, and enhance your forest's air, water and soil resources. For each resource element, consider:

1. What treatments/monitoring/protection is planned?
2. When will you implement treatments (season, year), follow-up activities, etc?
3. Where will the management take place: entire stand/unit, part of a stand, acres?

Table 2: Eligible Forest Stewardship Management Practices

Management Plan	Fence
Tree and Shrub Site Preparation o Tree/Shrub Site Preparation o Deep Tillage o Woody Residue Treatment	Irrigation o Irrigation Pipeline o Irrigation Reservoir o Irrigation water management o Irrigation system sprinkler
Nutrient Management	Mulching
Tree and Shrub Establishment o Tree/Shrub establishment o Riparian Forest Buffer o Alley Cropping o Multi-story cropping o Silvopasture o Windbreak/Shelterbelt establishment	Special Areas Practice o Critical Area Planting o Streambank Habitat Improvement o Streambank Crossing o Streambank and Shoreline Protection o Other Project Needs
Fuel Break	Trail Construction
Ground Cover Establishment o Conservation cover o Cover Crop o Riparian Herbaceous Cover	Forest Health and Protection o Integrated Pest Management o Animal Control o Other tree protection
Forest Stand Improvement	Tree and Shrub Pruning
Weed Control o Brush management o Herbaceous weed control	Monitoring and Maintenance o Access control o Upland wildlife habitat management

VI. Practice Implementation Schedule

In a table, clearly list all specific practices by year, total acreage, projected cost per acre, total cost, and associated cost-share. The Implementation Schedule should cover a period of at least 10 years even if there is no requested cost-share in some years. Cost projections can vary widely depending on your site and should be based on relevant and recent information and not simply estimations using the provided allowable cost-share rates. It is common for landowner project expenses to exceed the allowed cost-share rates, especially where real cost estimates are higher than established hold-down rates for a particular management practice (State FSP and NRCS EQIP cost-share rates may vary between programs). The FSP cost-share amounts requested for each management practice should not exceed the cost-share rates as listed in *Appendix B and C*.

All cost-share funds are paid on a reimbursement basis.

Example (use this format for each year. Include components where applicable)

Implementation Schedule Year 1

Practice Component	**Component***	**Units**	**Cost/Unit**	**Total Cost**	**Applicant Share**	**FSP Share**
Tree and Shrub Site Preparation	Tree/Shrub Site Preparation (490)	4 acres	$1,000	$4,000	$2,000	$2,000
Nutrient Management	(590)	4 acres	$200	$800	$400	$400
Tree and Shrub Establishment	Riparian Forest Buffer (391)	1000 seedlings	$4.00	$4,000	$2,000	$2,000
Groundcover Establishment	Conservation Cover (327)	2 acres	$300	$600	$300	$300
TOTALS				**$9,400**	**$4,700**	**$4,700**

*See *Appendix C* for more information on NRCS practice codes

VII. Budget Summary

The budget summary lists your projected cost-share, FSP share and total project costs per year for the length of the project. If you are receiving other private or public funding, please create additional columns for each source. Please use this format:

SAMPLE PROJECT BUDGET SUMMARY

YEAR	Total Budget	Landowner Share	Program Share	Other Funding Source
Year 1	$38,717	$22,177	$16,540	
Year 2	$24,882	$12,441	$12,441	
Year 3	$25,844	$13,274	$12,570	
Year 4	$19,660	$9,830	$9,830	
Year 5	$23,060	$11,530	$11,530	
Year 6	$23,060	$11,530	$11,530	
Year 7	$23,060	$11,530	$11,530	
Year 8	$14,750	$11,275	$3,475	
Year 9	$14,750	$11,275	$3,475	
Year 10	$5,250	$3,740	$1,510	
TOTALS	$213,033	$118,602	$94,431	$

Year one (1) begins upon contract execution, therefore dated years should not be listed in this table.

Economic Analysis for Commercial Timber Projects

If management objectives include commercial timber production, the plan must include an economic analysis such as a net present value or internal rate of return calculation. You should roughly estimate projected cost and income flows and consider their sensitivity to changes in economic factors such as price and risks. While it may be impossible to accurately predict financial returns over time or provide precise data on silvicultural systems, it is recommended that you consider possible outcomes in consultation with a qualified resource economist or extension forester. A good resource is "Financial Analysis for Tree Farming in Hawaii," available at http://www2.ctahr.hawaii.edu/oc/freepubs/pdf/RM-9.pdf. A

downloadable model spreadsheet is available on line at http://www2.ctahr.hawaii.edu/oc/freepubs/spreads/RM-9_forest_econ_calc.xls. Management plans that do not include a viable economic analysis for commercial timber will not be approved.

VIII. Required Maps

All maps must be at an appropriate and defined scale and include the following:

Legend and North arrow
Property boundary
Project boundary
Practice location
Existing and proposed roads
Watercourses

- **Location Map:** Illustrate the general property/project site location on the island and in relation to towns, major topographic features etc (This could be the same map as project proposal).

- **Topographic Map:** Provides specific property and project or unit boundaries clearly marked.

- **Project/Site Map:** Gives the location, orientation and layout of all management practices and other intended activities in the project area. Each practice location must be clearly illustrated in relation to the topography, watercourses and/or other significant natural and cultural features of the site. The map must also illustrate the layout and orientation of any proposed tree plantings such as windbreaks, forestry plantings, and restoration areas.

- **Other Map:** Additional maps may be included to further describe the property area and project. *The importance of good maps cannot be emphasized enough. Projects with inadequate maps or those that do not provide the level of detailed described above will be delayed or will not be funded.*

IX. Photographs of Project Site- Clearly shows existing site conditions and vegetation for each proposed project area are necessary. Aerial and/or satellite imagery is recommended.

X. Monitoring activities- Please describe all expected monitoring plans including the frequency and who will do it.

XI. Other Attachments if Available (not required)

- Existing forest stand inventories
- Maps: USGS, vegetation, roads/trails/soils, topography, archeological sites
- Sources of assistance and information, bibliography

[End of FSP Template]

Appendix A.

Environmental Compliance and Permits

Archeological and Historic Sites

As part of creating a management plan, please submit a letter asking that the State Historic Preservation Division (SHPD) verify that for the TMK of the proposed project area there are no archeological, burial or historic sites present. Send to:

Administrator
State Historical Preservation Division (SHPD)
601 Kamokila Blvd. #555
Kapolei, HI 96707

If you believe there may be such sites present on the project property then you must also submit a letter to the same address telling them of your plans and notating the possible sites. SHPD will review your plans to determine whether an archeological inventory survey must be done. If so, permitted archeologists in the state are listed on the SHPD website: http://www.hawaii.gov/dlnr/hpd/archcon.htm

For more information see: http://www.hawaii.gov/dlnr/hpd/hpgreeting.htm.

Grading Permits and Soil Conservation Plans

Grading, stockpiling, grubbing, and trenching may require permits for soil disturbing work. A Special Management Area permit is required if the planned work is in the Special Management Area. This is mostly work near the coastal areas and is tied to Coastal Zone Management program requirements. **Each county is responsible for issuing this permit.** In some cases, an approved soil conservation plan may be acceptable. Contact NRCS or your local Soil and Water Conservation District for more information or see http://www.hi.nrcs.usda.gov/.

For more information on County Grading regulations and permits see:

O'ahu http://www.co.honolulu.hi.us/refs/roh/14a10_19.htm
Section 14-14 for ordinances
http://www.honoluludpp.org/download/permits/permitlistings.asp?p_TypeID=4
For applications and information

Hawai'i http://www.hawaii-county.com/directory/dir_pubworks.htm
East Hi: (808) 961-8321 or **West Hi:** (808) 327-3520

Maui http://ordlink.com/codes/maui/index.htm
Or call (808) 270-7242.

Kauai http://www.kauai.gov/Default.aspx?tabid=133
(Under Forms, Applications, and Instructions)

Appendix A. Environmental Compliance and Permits

Environmental Assessments (EA)

Plans that include the establishment of timber with the intent of eventual harvest and projects involving fencing an area over 10 acres must be accompanied by an Environmental Assessment (EA), HRS §343. The FSP Coordinator can provide you with samples of approved stewardship plans and EAs. Incorporating local communities and cultural assessment (when appropriate) is an important part of the EA process. A helpful guidebook from the Office of Environmental Quality Control, available on the web at: http://hawaii.gov/health/environmental/oeqc/index.html.

From the guidebook:

> *"An EA is an informational document prepared by the proposing agency or the private applicant and used to evaluate the possible environmental effects of a proposed action. The environmental assessment must give a detailed description of the proposed action or project and evaluate direct, indirect and cumulative impacts. The document must consider alternatives to the proposed project and describe any measures proposed to minimize potential impacts. The public has 30 days to review and comment on a draft environmental assessment. After the draft environmental assessment has been finalized and public comments responded to, the agency proposing or approving the action reviews the final assessment and determines if any "significant"environmental impacts are anticipated.*
>
> *If the agency determines that the project will not have a significant environmental impact, it issues a finding of no significant impact (FONSI). This determination allows the project to proceed without further study. Within 30 days of the notice of this finding, the public may challenge an agency's determination by filing suit in circuit court. If the agency determines that the action may have a significant impact, a more detailed environmental impact statement (EIS) be prepared. An EIS preparation notice is then issued and undergoes an additional 30-day comment period to define the scope of the draft EIS. Publication of an EIS preparation notice initiates a 60 day period during which an aggrieved party may challenge the determination in court."*

Conservation District Use Permit

State Land Use Law established the State Land Use Commission (LUC) in 1961, and granted the LUC the power to zone all lands in the State into three districts: Agriculture, Conservation, and Urban (the Rural District was added in 1963). DLNR was given jurisdiction over the Conservation District, formulated subzones and regulates land uses and activities therein.

The Conservation District has five subzones: Protective, Limited, Resource, General and Special. Omitting the Special subzone, the four subzones are arranged in a hierarchy of environmental sensitivity, ranging from the most environmentally sensitive (Protective) to the least sensitive (General); the Special subzone is applied in special cases specifically to allow a unique land use on a specific site. Subzone maps for each island are available on the web: www.hawaii.gov/dlnr/occl/.

These subzones define a set of "identified land uses" which may be allowed only by discretionary permit. The Office of Conservation and Coastal Lands (OCCL) can accept a permit application for an

identified land use listed under the particular subzone covering the subject property. Conservation District Use Application forms and contact information is available on the web at: www.hawaii.gov/dlnr/occl/documents.php.

Threatened and Endangered Species

If you plan to process, collect, propagate, out-plant or sell threatened or endangered species as part of your Forest Stewardship project please contact the Hawaii State Botanist for instructions and permits at 587-0166.

Safe Harbor Agreements

Environmental Defense, the U.S. Fish and Wildlife Service and DLNR encourage private landowners to restore and maintain habitat for endangered species without fear of incurring regulatory restrictions. If you feel this could happen as a result of the restoration or conservation process, you should consider initiating a Safe Harbor Agreement. More can be found at www.environmentaldefense.org/article.cfm?ContentID=136 or by contacting DLNR/DOFAW 1151 Punchbowl St., Rm. 325 Honolulu, HI 96813 Telephone (808) 587-0166 Fax (808) 587-0160

Appendix B.

State Forest Stewardship Program

State of Hawaii Forest Stewardship Program Agreements

Hawaii Forest Stewardship Program contract agreements generally cover cost-share assistance for the 10 year period of the management plan and require an additional maintenance period, for which the term is negotiable between the applicant/landowner and the State. The State program allows eligible applicants, whose objectives do not include commercial timber production, to enter into contracts with term length ranging from 10 to 30 years, which include the cost-share assistance period. For applicants interested in commercial timber production, contract term lengths must be at least 30 years and include a payback provision as described in the "*Payback Provision and Taxes*" section below. All agreements must follow the State's General Conditions and include special conditions based on your management plan.

Once your management plan has been submitted for the State program, the project will be reviewed and ranked for funding priority. Once selected for funding a contract agreement will be generated by DOFAW staff and submitted for your review. The Board of Land and Natural Resources is required to authorize all State Forest Stewardship Agreements and in some cases State of Hawaii Governor's approval may also be required. The BLNR may approve, deny or request that adjustments be made to management plans and contract agreements to reflect current priorities or budget concerns. If approved, you will be asked to sign the agreement and submit the contract agreement for finalization. The agreement starts on the date of final approval by the BLNR Chairperson. If you begin your project before all parties sign and prior to State authorized execution of the contract, you will not be reimbursed for expenses incurred before the agreement date. You will receive a Forest Stewardship recognition sign to post on your project property.

The State Forest Stewardship Program provides for 50% cost-share reimbursement on all approved management plan practices at the allowable cost-share rates set for the program (see below). Enrolled parties are asked to submit project process reports and practice cost-share reimbursement requests on at least a bi-annual basis. After a site visit to verify your work under the reimbursement request, DOFAW will mail a payment for the completed management practices.

Allowable Cost-Share Rates for the State Forest Stewardship Program

When you create your project budget, you should use and consider the following allowed cost-share rates for the State Forest Stewardship Program. The State Forest Stewardship Program and the NRCS Environmental Quality Incentive Program utilize different cost-share rates for assistance funding. The allowed cost-share rates for the State Forest Stewardship Program are included below.

The State Forest Stewardship Program includes total low to high cost-share amounts for each allowed practice. The State will reimburse at 50% cost-share for each practice. If you think your costs will be higher than the allowed rates you will need to justify these rates to the FSP Coordinator; this may require documentation such as quotations from existing companies that provide the services or materials. Rates range from Low to High and the selection of a rate will depend on the circumstances of each project or practice. In your management plan you will need to justify the use of the high rates or selected rates for practices that have no rates established. Based on Committee and State approval, your contract agreement for financial assistance will set the rates for your particular project.

Appendix B. State Forest Stewardship Program

Practice	Unit	State Share Low	State Share High
Forest Stewardship Management Plan	per plan	$1,500	$5,200
Tree and Shrub Site Preparation	per acre	$200	$1,000
Fence	per foot	$2.50	$7.00
Nutrient Management	per acre	$50	$350
Tree and Shrub Establishment	per seedling	$0.50	$6
Groundcover Establishment	per acre	$400	$1,400
Irrigation	per foot	$0.50	$6
Mulching	per square foot	$0.07	$0.14
Weed Control	per acre	$100	$300
Fuelbreak	per acre	$150	$500
Windbreak	per seedling	$0.50	$6
Special Area Practice	per acre/tree/unit	*	*
Forest Stand Improvement	per acre	$100	$500
Tree and Shrub Pruning	per acre	$100	$300
Trail Construction	per foot	$2	*
Forest Health and Protection	per acre/foot/unit	*	*
Monitoring	per acre	$10	$75

**The applicant must obtain at least 3 written quotes for the proposed work and/or consult with the FSP Coordinator to determine the allowable cost-share.*

***NOTE**: Rates in the above table represent 50% of the actual cost of installing the practice, which is the amount the State will contribute to a practice as a part of 50% cost-share agreement.*

Allowable reimbursements are subject to a variety of factors including project scale, type, actual project costs, and the anticipated availability of program funding. The FSP Coordinator may allow exceptions to the listed cost-share rates if the requested amounts are justifiable. To date, projects requesting more than $75,000 per year have not been approved.

Allowable In-Kind Rates for State Forest Stewardship

The Hawaii Forest Stewardship Program allows for the use of in-kind match for projects receiving financial assistance under contract agreement with the State. The below table includes the allowed in-kind cost-share rates.

In-kind means non-cash contributions to the project. When calculating your 50% required contribution to the project, you should use these rates to determine labor and equipment cost estimates. If you want to use higher rates, please provide justification (quotes) in your plan and/or contact the FSP Coordinator.

Appendix B. State Forest Stewardship Program

Hourly Rates for In-kind Contributions		
Labor costs include fringe		Current
General Hand Labor	per hour	$21
Specialized Hand Labor	per hour	$27
Line Posts	each	$18
Corner Posts	each	$20
Equipment with Operator		
1/2 and 3/4 ton truck	per hour	$35
1 ton truck	per hour	$40
1 1/2 ton truck	per hour	$45
2 ton truck	per hour	$50
2 1/2 ton truck	per hour	$55
5 ton truck	per hour	$65
20 ton tandem dump truck	per hour	$85
12 ton tandem dump truck	per hour	$75
2 and 4 wheel drive tractor	per hour	$60
2 wheel drive tractor >40 hp	per hour	$70
D-2 or TD6 w/ attachments	per hour	$75
D-4 or TD9 w/ attachments	per hour	$105
D-6 or TD14 w/ attachments	per hour	$120
D-7 or TD18 w/ attachments	per hour	$150
D-8 or TD20 with attachments	per hour	$180
D-9 or TD25 w/ attachments	per hour	$225
Back-hoe	per hour	$85
Loader	per hour	$100
Compressor	per hour	$25
Power saw	per hour	$25
Power post hole digger	per hour	$35
Power sprayer	per hour	$30
Bobcat	per hour	$65
Manlift	per hour	$35
Mulcher	per hour	$25

Pay-back Provisions and Taxes

If landowners/lessees sell or transfer all or part of the stewardship managed property during the term of the approved contract agreement, they are required to pay back to the state all of the cost-share funds received in the past three years (or the portion of funding that corresponds to a pro-rated share of that portion of the managed property that is sold or transferred). *The landowner/lessee or contractor would not be required to reimburse the State for the cost-share assistance received if the new landowner contractually agrees to assume responsibility for the term remaining on the Forest Stewardship contract agreement.*

Cost-share reimbursement payments are considered as income and are thus normally subject to state and local taxes. However, depending upon your management activities, payments may be exempt from taxes. A guide to federal income tax regulations affecting private forests, and other resources are available on line at: http://www.fs.fed.us/spf/coop/programs/loa/tax. In addition, you may be eligible for

real property tax reductions or incentives because of your commitment to long-term forest management. For more information, contact your county tax office.

If the purposed stewardship plan includes an objective for commercial timber production, you will be required to pay back to the State a percentage of the funding assistance that is received through the program with each future commercial timber harvests as set forth in the contract. This pay back is typically 5 to 10 percent of total grant funding received, but the amount is negotiable. A payback provision will be included as a special condition of the contract, stipulating that this provision will survive the term length of the contract.

Appendix C.

FSP-NRCS Financial Incentive Programs

NRCS EQIP Contact and Eligibility

As an alternative to State Forest Stewardship Program funding, completed Forest Stewardship Plans may be submitted to your local USDA-Natural Resource Conservation Service (NRCS) office for cost-share assistance under their financial incentive programs. Available NRCS financial programs that can fund FSP management plans include Environmental Quality Incentive Program (EQIP), Wildlife Habitat Incentive Program (WHIP), Hawaii Conservation Reserve Enhancement Program (CREP).

NRCS has eligibility requirements and cost-share schedules that should be considered as you develop your FSP management plan.

Contact information for NRCS offices can be found in the United States Government section of the telephone book under "Agriculture, Department of" or at this website: http://www.pia.nrcs.usda.gov/programs/

NRCS EQIP funded contracts must address at least one specific "Natural Resource Concern" occurring on your site; see the Forest Stewardship Project Proposal for more information on natural resource concerns. EQIP contracts are generally for a 3 to 5 year period. The Forest Stewardship Advisory Committee, FSP Coordinator, and/or a NRCS Soil Conservationist can assist you in identifying natural resource concerns on your site for incorporation into your FSP management plan.

The complete list of natural resource concerns is available at: http://efotg.nrcs.usda.gov/efotg_locator.aspx?map=HI - click on the image of any island, then look in the left-side column, click on Section III, and open "Quality Criteria, Quality Criteria Table." Some of the more likely resource concerns that could be addressed by forestry practices are included in the Project Proposal Form (on page 13).

NRCS Practices

If you are considering submitting your Forest Stewardship Plan to NRCS financial incentive program, please include NRCS practices and practice codes in your proposed Management Practices (as listed in your management plan). The following table will assist you. In many cases there are multiple NRCS practices that correlate to one FSP practice, in which case it is important to describe the planned work under each proposed management practice.

The complete list of all NRCS Practice Standards and Specifications can be found at: http://efotg.nrcs.usda.gov/efotg_locator.aspx?map=HI. Click on the image of any island, then look in the left-side column, click on Section IV and open Current Practice Standards, Specifications, and Jobsheets. This information will help you understand NRCS Practice Standards.

Appendix C. FSP-NRCS Environmental Quality Incentive Program

FSP-NRCS Practices and Practice Codes

FSP Management Practices	NRCS Practice Code	NRCS Practice Names
Tree and Shrub Site Preparation	490 384 324	Tree/Shrub Site Preparation Woody Residue Treatment Deep Tillage
Fence	472 382	Access Control (for feral ungulate-proof fence) Fence (for other fences)
Nutrient Management	590	Nutrient Management
Tree and Shrub Establishment	612 391 311 379 381 380	Tree/Shrub Establishment Riparian Forest Buffer Alley Cropping (for agroforestry) Multistory Cropping (for agroforestry) Silvopasture Windbreak/Shelterbelt establishment
Irrigation	430 436 449 442	Irrigation Pipeline Irrigation Reservoir Irrigation water management Irrigation sprinkler system
Mulching	484	Mulching
Weed Control	314 315	Brush Management (for range and pasture lands) Herbaceous Weed control
Fuelbreak	383	Fuelbreak
Special Areas Practice	342 395 578 580	Critical Area Planting (for degraded lands) Stream Habitat improvement and Management Stream Crossing Streambank and Shoreline protection
Trail Construction	383	Fuelbreak (for fire pre-suppression)
Forest Stand Improvement	666	Forest Stand Improvement
Windbreak	380	Windbreak/Shelterbelt Establishment
Tree and Shrub Pruning	660	Tree and Shrub Pruning
Forest Health and Protection	595	Integrated Pest Management
Monitoring	472 645	Access Control Upland Wildlife Habitat Management

After your NRCS EQIP application is approved, and NRCS Soil Conservationist will assist you with formulating the final list of NRCS practices and completing all necessary documentation based on information included in your FSP management plan.

NRCS EQIP Cost-Share Rates

When you create your project budget, you should use and consider the following allowed cost-share

rates for the NRCS EQIP. The NRCS EQIP and the State Forest Stewardship Program utilize different cost-share rates for assistance funding. The allowed cost-share rates for NRCS EQIP are found here http://www.pia.nrcs.usda.gov/programs/index.html under EQIP Program Payment schedule.

Appendix D.

Forest Stewardship Plan Signature Page

Professional Resource Consultant Certification: I have prepared (revised) this Forest Stewardship Plan. Resource Professionals have been consulted and/or provided input as appropriate during the preparation of this plan.

Prepared by: _____
Professional Resource Consultant's Name

Professional Resource Consultant's Signature: _____

Date: _____

Applicant Certification: I have reviewed this Forest Stewardship Plan and hereby certify that I concur with the recommendations contained within. I agree that resource management activities implemented on the lands described shall be done so in a manner consistent with the practices recommended herein.

Prepared for: _____
Applicant's Name

Applicant's Signature: _____

Date: _____

State Forester's Approval: This plan meets the criteria established for Forest Stewardship Plans by Hawaii's Forest Stewardship Advisory Committee. The practices recommended in the plan are eligible for funding according to state of Hawaii Forest Stewardship Program guidelines and administrative rules.

Approved by: _____
State Forester's Name

State Forester's Signature: _____

Date: _____

Forest Stewardship Advisory Committee Approval: This plan was reviewed and approved by the Forest Stewardship Advisory Committee on _____
Date of approval

Appendix E.

Useful Resources

NRCS has developed Ecological Site Descriptions for most of the Island of Hawaii. These are descriptions of different forest types, including detailed native species lists, that correlate to specific soil types and the NRCS soil maps. They are useful for making specific site native species planting recommendations. Current Ecological Site Descriptions are available at: http://efotg.nrcs.usda.gov/efotg_locator.aspx?map=HI. Click on the island image, then click on Section II in the left-side column.

Archeological Consultants http://hawaii.gov/dlnr/hpd/archcon.htm

Best Management Practices http://www.state.hi.us/dlnr/dofaw/pubs/BMPs_bestmanagement.pdf

Economics http://www2.ctahr.hawaii.edu/oc/freepubs/pdf/RM-9.pdf
http://www2.ctahr.hawaii.edu/oc/freepubs/spreads/RM-9_forest_econ_calc.xls

Environmental Assessments http://hawaii.gov/health/environmental/oeqc/index.html

Forestry Consultants http://www.hawaiiforest.org/

Forestry in Hawaii (general) www.ctahr.hawaii.edu/forestry/
http://www2.ctahr.hawaii.edu/forestry/links.html

MAPS- Tax Maps
- Hawaii County http://www.hawaiicounty.gov/real-property-tmk-maps/
- Maui County http://www.mauipropertytax.com/
- Kauai County http://www.kauai.gov/default.aspx?tabid=433
- Oahu http://www.honolulupropertytax.com/Main/Home.aspx

Topographic Maps http://trails.com/

NRCS Web Soil Survey http://websoilsurvey.nrcs.usda.gov

Natural Resources Conservation Service http://www.pia.nrcs.usda.gov/

Soil Tests from UH http://www.ctahr.hawaii.edu/site/downloads/adsc/price_list.pdf

State Historic Preservation http://hawaii.gov/dlnr/hpd/hpgreeting.htm

Taxes (Federal Income) http://www.fs.fed.us/spf/coop/programs/loa/tax

US Fish & Wildlife Service Programs http://www.fws.gov/pacificislands/

Noxious Weed List http://hawaii.gov/hdoa/admin-rules/subtitle-6-division-of-plant-industry/AR-68.pdf/at_download/file

Hawaii Pacific Weed Risk Assessment http://www.plantpono.org/
https://sites.google.com/site/weedriskassessment/home
http://www.botany.hawaii.edu/faculty/daehler/wra/default2.htm

Appendix F.

Natural Area Reserve System

If you are wondering if your site can be considered a "potential natural area preserve" please review these criteria. The following criteria are adopted as important guides for the Natural Area Reserves Commission in selecting areas for the Natural Area Reserves System. *However, the Commission shall exercise its prerogative* of judgment with regard to these criteria and other criteria in selecting and recommending areas to be included in the Natural Area Reserves System.

Representativeness: Each selected Natural Area shall be representative of one or more major, natural, relatively unmodified ecosystems, geologic or physiographic features, or habitats containing endangered species of fauna or flora. The description of a proposed area shall include details of the features that make the area distinctive, unique, significant, or representative. The term representative as applied to ecosystems shall be interpreted in relation to macroclimatic zonation to ensure a balanced geographic distribution of natural areas as representative ecosystems.

Scientific Value: Each Natural Area shall have significant potential for scientific study, for teaching, for preservation of distinctive biota or other natural features, or for preserving natural genetic material. The description of a proposed area shall include details of the scientific attributes of the area.

Administrative: Each Natural Area shall be identifiable on maps and on the ground. It should be reasonably protectable from pests and from physical damage and, legally, from encroachment. Access to the area should be in conformance with the nature and purpose of the area. Utilities, communication facilities, and other right of way developments should be avoided as much as possible. Administrative or management factors should be detailed in the description of each proposed area.

Size of Areas: Each Natural Area shall be large enough, but no larger than necessary, to accomplish the particular purpose of establishing that Natural Area. A desired size is that which will provide essentially unmodified conditions in the interior portion. The cost and feasibility of protecting the area will have a bearing on the size. Some areas may be less than an acre while others may exceed 10,000 acres, where a special need is demonstrated.

Number of Areas: As many as possible of the major terrestrial and aquatic plant and animal communities and distinctive geologic features on each island should be represented in the Natural Area Reserves System. However, the Natural Area Reserves System shall not include unnecessary duplications of ecosystems or geologic features already protected in Federal Wildlife Refuges, National Parks, or private conservation groups.

Ownership: Natural Areas shall be composed of lands owned or legally controlled by the State in perpetuity. Privately owned areas desired for the Natural Area Reserves System may be obtained by gift, devise, purchase, or eminent domain as specified in the Act. Federal lands shall not be designated as Natural Areas under Act 139.

BEST MANAGEMENT PRACTICES

FOR

MAINTAINING WATER QUALITY

IN HAWAII

State of Hawaii
Department of Land and Natural Resources
Division of Forestry and Wildlife
February 1996

FOREWORD

Best Management Practices (BMPs) are effective, practical, structural or nonstructural methods which prevent or reduce the movement of sediment, nutrients, pesticides and other pollutants from the land to surface or ground water, or which otherwise protect water quality from potential adverse effects of silvicultural activities. These practices are developed to achieve a balance between water quality protection and the production of wood crops within natural and economic limitations.

A thorough understanding of BMPs and the flexibility in their application are of vital importance in selecting BMPS which offer site specific control of potential nonpoint source pollution. With each situation encountered at various sites, there may be more than one correct BMP for reducing or controlling potential nonpoint source pollution. Care must also be taken to select BMPs that are practical and economical while maintaining both water quality and the productivity of forest land.

The Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500 (and as amended by Sec. 319, 1986), require the management of nonpoint sources of water pollution from sources including forest-related activities. BMPs have been developed to guide forest landowners, other land managers and timber harvesters toward voluntary compliance with this act. Maintenance of water quality to provide "fishable" and "swimmable" waters is central to this law's objectives. The Environmental Protection Agency (EPA) recognizes the use of BMPs as an acceptable method of reducing nonpoint source pollution.

Nonpoint source is diffuse pollution that comes from almost everywhere; it even occurs naturally to a certain extent. The amount of pollutants from any particular spot is small and insignificant, but when combined from over the landscape, can create water quality problems. **Although it is unrealistic to expect that all nonpoint source pollution can be eliminated, BMPs can be used to minimize the impact of forestry practices on water quality. These practices must be reasonable, achievable and cost effective.** The adoption and use of BMPs will provide the mechanism for attaining the following water quality goals:

* to maintain the integrity of stream courses;

* to reduce the volume of surface runoff originating from an area of forest management disturbance and running directly into surface water;

* to minimize the movement of pollutants i.e. pesticides, nutrients, petroleum products, etc. and sediment to surface and ground water;

* to stabilize exposed mineral soil areas through natural or artificial revegetation means.

The intent of this guide is to promote better stewardship of the forest resources. This guide delineates environmentally responsible land management methods which, when applied properly, minimizes adverse impacts on the forest ecosystem and maximizes landowner objectives. Unusual situations may arise or pollution control measures other than those recommended here may be found. In these cases, common sense is most often the best guide.

Information presented in this guide is not to be used as the basis for setting water quality standards or as the basis of required use of watershed protection practices. Compliance with any watershed protection practices would be on a voluntary basis backed up with a public water quality education and awareness program. Changing of water quality standards or the required use of protection practices should not be attempted without careful study of the beneficial effects gained from modifying existing silvicultural practices now in use.

INTRODUCTION

The Division of Forestry and Wildlife (DOFAW) is mandated by HRS, Chapter 183 to "...devise ways and means of protecting, extending, increasing, and utilizing the forests and forest reserves, more particularly for protecting and developing the springs, streams, and sources of water supply to increase and make that water supply available for use..."

The number one resource that is generated by the forest is water. Since the establishment of the Department of Agriculture and Forestry in 1900, the concern for the protection of forest lands for the purpose of water has been a high priority. Fencing to keep out wild cattle and other feral animals and reforestation efforts to re-establish watersheds have been the key to the continuance of the production of high quality water.

In 1961, Hawaii created, by law, the nation's first statewide zoning districts, and today approximately 95% of the Hawaii's four million acres are zoned for agricultural or conservation uses. The Conservation district, which is under the jurisdiction of the Department of Land and Natural Resources (DLNR), encompasses almost one-half of the State, of which one million acres is state-owned. The majority of Conservation lands are covered by forests, but also contain grasslands, coastlines, cliffs, offshore islets, and wetlands. Vegetative communities include lowland and montane rainforests and unique examples of tropical biodiversity, much of it endangered.

The Division of Forestry and Wildlife recognizes the need for responsible stewardship of the natural resources, which include soil and water. **The success of BMPs to protect water quality within Hawaii depends on mutual cooperation and trust among landowners, industry, environmentalists, wood producers, regulatory agencies, governmental officials, and the general public.** All have an interest in good land management as it relates to water quality.

THE FOREST/WATER RELATIONSHIP

The forest and water resources are mutually dependent upon one another. Forests depend on water, namely rain, surface water, and groundwater for their growth and reproduction. Major long-term changes in the water supply can cause permanent changes in the content, quality and vitality of forest lands.

On the other hand, surface and groundwater quantity and quality are largely influenced by the surface on which rain falls and through which it percolates. The tremendous filtering capacity of forest lands provide effective and high quality groundwater recharge.

Hawaii's streams and aquifers all benefit from the presence of forests. In addition to these water quality benefits, forests provide needed wood and fiber products, wildlife habitat, aquatic resources and habitat, recreation values and aesthetic benefits. It is in managing forests for these benefits that damage to the water resource can result. Following is a brief discussion of the most commonly used forest management practices and the impacts they can have on the quality of the water resource.

Timber Harvesting

The removal of trees from a site has little impact on water quality, as long as the trees do not provide vital shade to streams and as long as the slope of the land is not excessive. The natural warmth of many streams can be exaggerated by removing shading vegetation from their banks. Increased water temperature promotes lower dissolved oxygen levels, placing stress on fish and other aquatic organisms.

Removing timber per se does not directly cause significant water quality changes, since ground cover is not excessively disturbed during proper logging operations. On steep slopes, however, careless timber removal can increase the likelihood of runoff and soil loss. This may lead to water quality degradation as well as a loss of site productivity. Steep areas should therefore be logged carefully using proper harvesting techniques for the sake of both water quality protection and site protection.

Road Construction and Drainage Techniques

All facets and phases of a sound forest management program rely heavily on accessibility to the forest. Consequently, temporary and permanent access roads are necessary components of all management programs. They are also one of the most costly investments made in a forests.

Temporary access roads are constructed to facilitate harvesting operations, site preparation and planting and often abandoned after the new stand is established. When abandoned, these temporary roads are normally allowed to revegetate naturally or are planted with trees.

Pollutants from Silvicultural Activities

The major types of water pollutants that can be generated from forest management disturbances to the forest ecosystem include sediment, nutrients, pesticides, and debris.

1) Sediment

Sediment is the most common pollutant resulting from silvicultural activities. Sediment principally results from erosion of soil, but may also include organic matter. Excessive sediment upsets balanced ecology within streams by smothering bottom dwelling organisms in the water, interfering with photosynthesis by reducing light penetration, serving as carriers of nutrients and pesticides, inhibiting fish reproduction and altering stream flow.

2) Nutrients

Nutrients, primarily phosphorous and nitrogen fertilizers, are sometimes applied to the forest to stimulate tree growth. Soluble nutrients may reach surface or ground water through runoff, seepage, and percolation. Insoluble forms may be absorbed on soil particles and reach water by direct wash-off of debris and recently applied fertilizer. Excessive nutrients lead to an imbalance in natural life cycles of water bodies.

3) Pesticides

Pesticides, if applied during silvicultural activities, may be soluble or insoluble. Pesticides in surface or ground water may result in toxicity problems, affecting water quality and food sources for aquatic life.

4) Debris

Tree limbs, tree tops, and other waste materials are the principal organic pollutants from silviculture. They reach streams through direct pushing or felling into water drainages, and washout during storms. Organic materials may place an oxygen demand on the receiving water body during the decomposition process. In addition, associated problems may include odor, color, taste and nutrients. Inorganic material such as oil cans and pop bottles are also considered nonpoint source debris.

BEST MANAGEMENT PRACTICES

1.0 Forest Roads

Standards and Use

Forest roads are managed to provide adequate access to lands for timber management, fire suppression, wildlife habitat improvement and a variety of dispersed and developed recreational activities. Generally, these are low volume roads that must carry heavy loads for short periods of time. The potential for adverse impacts from forest roads exists in areas where steep slopes, erodible soils, or where forest roads are located near water. **Forest roads cause more erosion than any other forestry activity.** Most of this erosion can be prevented by locating, constructing, and maintaining roads to minimize soil movement and pollution of streams. The need for higher standard roads can be alleviated through better road-use management. Design roads to the minimum standard necessary to accommodate anticipated use and equipment.

Planning, Design, and Location

A well planned access system is a sound method of reducing erosion and sedimentation in areas requiring frequent or temporary access. Proper location and construction of roads will provide for safety, longer operating periods, lower maintenance and operating costs, and minimal impacts to water quality. The value of the resource served and site characteristics will influence the choice of road construction standards and maintenance activities. The following practices are recommended:

(1) Use a design to minimize damage to soil and water quality.

(2) Roads should be designed no wider than necessary to accommodate the immediate anticipated use.

(3) Design cut and fill slopes to minimize mass soil movement.

(4) Provide culverts, dips, water bars, and cross drainages to minimize road bed erosion.

(5) Design bridge and culvert installations using stream flow data, with a margin of safety proportional to the importance of the road and the protected resources.

(6) Provide drainage where surface and groundwater cause slope instability.

(7) Avoid diverting water from natural drainage ways. Dips, water bars, and cross drainage culverts should be placed above stream crossings so that water can be filtered through vegetative buffers before entering streams.

(8) Locate roads to fit the topography and minimize alterations to the natural features.

(9) Avoid marshes and wetlands.

(10) Minimize the number of stream crossings.

(11) Cross streams at right angles to the stream channel.

(12) A road may not be located in a Streamside Management Zone (SMZ) except where access is needed to a water crossing, or where there is no feasible alternative. A road in any SMZ must be designed and located to minimize adverse effects on fish habitat and water quality.

Construction

Once the road's location and design is staked out, road construction begins. Timber is out, logs and vegetation are removed and piled along the lower side of the right-of-way.

Most forest roads are built by excavating a road surface. Road design and layout on-the-ground show machine operators the proper cut slopes and indicate cut slope steepness. The bulldozer starts at the top of the cut slope, excavating and sidecasting material until the desired road grade and width is obtained. Material from cuts is often pushed in front of the blade to areas where fill is needed. Road fill is used to cover culverts and build up flat areas. Since fill must support traffic, it needs to be spread and compacted in layers to develop strength. The following practices are recommended:

(1) Construct roads when moisture and soil conditions are not likely to result in excessive erosion or soil movement.

(2) The boundaries of all SMZs shall be defined on the ground prior to the beginning of any earth-moving activity.

(3) Construct a road sufficient to carry the anticipated traffic load with reasonable safety and with minimum environmental impact.

(4) When using existing roads, reconstruct only to the extent necessary to provide adequate drainage and safety.

(5) Avoid construction during wet periods, when possible, to minimize unnecessary soil disturbance and compaction.

(6) Road grades should be kept at less than 10%, except where terrain requires short, steep grades.

(7) Minimize the number of stream crossings. Stream crossing construction should minimize disturbance of the area in which the crossing is being constructed.

(8) As slope increases, additional diversion ditches should be constructed to reduce the damages caused by soil erosion; ditches, adequate culverts, cross drains, etc., should be installed concurrent with construction.

(9) To control erosion, cut and fill slopes should conform to a design appropriate for the particular soil type and topography.

(10) Stumps, logs, and slash should be disposed of outside of the road prism; in no cases should they be covered with fill material and incorporated into road beds.

(11) Stabilize the side banks of a road during construction to aid in the control of erosion and road deterioration; this may require mesh or other stabilizing material in addition to planting and/or seeding and other structural measures.

(12) Water bars should be located to take advantage of existing wing ditches and cross drainage. Water bars should be constructed at an angle of 30 to 45 degrees to the road. Water bars should be periodically inspected and damage or breeches should be promptly corrected. Install water bars at recommended intervals to provide the drainage. Water bar spacing recommendations are as follows:

Grade of Road	Distance Between Water bars
2%	250 ft.
5%	135 ft.
10%	80 ft.
15%	60 ft.
20%	45 ft.
25%	40 ft.
30%	35 ft.
40%	30 ft.

Water bars may need to be spaced closer together depending on soil type and rainfall.

(13) Bridges and overflow culverts should be constructed to minimize changes in natural stream beds during high water.

(14) Culverts on perennial streams should be installed low enough to allow passage of aquatic life during low water.

Maintenance

Maintenance of active and inactive roads shall be sufficient to maintain a stable surface, keep the drainage system operating, and protect the quality of streams. The following are recommended:

(1) Maintenance should include cleaning dips and crossdrains, repairing ditches, marking culverts inlets to aid in location, and clearing debris from culverts.

(2) Keep culverts, flumes, and ditches functional before and during the rainy season to diminish danger of clogging and the possibility of washouts. This can be done by clearing away any sediment or vegetation that could cause a problem. Provide for practical and scheduled preventative maintenance programs for high risk sites that will address the problems associated with high intensity rainfall events.

(3) Conduct road surface maintenance as necessary to minimize erosion of the surface and subgrade.

(4) During operations, keep the road surface crowned or outsloped, and keep the downhill side of the road free from berms except those intentionally constructed for protection of fill.

(5) Avoid using roads during wet periods if such use would likely damage the road drainage features.

(6) Water bars should be inspected after major rain storms and damage or breeches should be promptly corrected.

Harvesting - Temporary Access Roads and Landings

(1) The location of temporary access roads (logging roads) should be planned before operations begin.

(2) Road construction should be kept to a minimum.

(3) Landings should be located to minimize the adverse impact of skidding on the natural drainage pattern.

(4) Logging roads and landings should be located on firm ground.

(5) Landings should be kept as small an area as possible.

(6) When operations are completed, provisions should be made to divert water run-off from the landings and roads.

2.0 Pre-Harvest Planning

Pre-harvest planning is the collection of information about the area to be harvested and the synthesis of that information into an effective environmental plan. This plan will consider the silvicultural prescription for the species and site, the best estimate of the time and method of harvest and any post-harvest site preparation and reforestation activities.

At this stage, it is assumed that all federal, state, and local government regulations regarding harvesting have been met.

An effective pre-harvest plan will take into consideration all aspects of the timber harvest which may lead to water quality degradation and plan for the implementation of BMPs which will minimize or avoid the adverse effects of the operation. The objective of pre-harvest planning from the perspective of non-point source pollution is to determine which BMPs are necessary to protect water quality and how those BMPs will be implemented. The following is recommended:

(1) A pre-harvest plan should include the following information:

A. Physical and administrative description

1. Property boundaries & administrative boundaries (zoning, etc.)
2. Topography
3. Location of streams and drainages
4. Location of SMZs and buffer strips
5. Forest types
6. Soil types
7. Areas of ecological and/or archaeological concerns

B. Management Activities

1. Design and construction techniques for all new roads, skid trails, and landings or modification of existing roads, skid trails and landings.
2. Felling and bucking techniques
3. Yarding systems and layout
4. Planned stream crossings
5. Disposal of waste materials (machine lubricants)
6. Post-harvest site preparation
7. Reforestation activities

(2) The use of topographic maps, road maps, aerial photos, forest type maps, and soil surveys in combination with field reconnaissance is essential to determine site conditions and plan operations.

(3) Field reconnaissance with a trained forester or one who is knowledgeable about the specific area is highly recommended.

(4) Preliminary planning should consider the maintenance of existing drainage patterns and the location of environmentally sensitive areas such as streams, wet areas, and high erosion hazard areas.

(5) The design of roads, skid trails, and landings shall be integrated to minimize their impact.

(6) The grade of logging roads and skid trails should be less than 10% when possible, with 3-5% being the norm. Long, straight, unbroken grades are to be avoided. Adequate surface drainage shall be provided.

(7) Time the harvesting activity for the season or moisture conditions when the least impact occurs.

(8) A final pre-harvest site review shall be conducted by management so that road alignments and other considerations can be visually checked prior to road construction. The reconnaissance plan shall be modified as necessary to make desirable adjustments based on the final site review.

2.1 Timber Harvesting

Standards and use

Timber harvesting is an integral part of most forest management programs. Harvesting operations cause a temporary disturbance in the forest as well as diminish water quality. However, it can be conducted in a manner where the impact to water quality is minimized and the re-establishment of vegetative cover is realized. Guidelines to help reduce the potential for nonpoint source pollution from harvesting trees are as follows:

Felling and Bucking

(1) Careful felling can minimize the impact of subsequent phases of the logging operation.

(2) Trees should not be felled into streams, except where no safe alternative exists. In the latter case, such trees should be removed promptly.

Skidding

(1) Skidding should be done so as to avoid disrupting natural drainage and to prevent excessive soil displacement.

(2) Stream channels or road ditches should not be used as skid trails.

(3) Skid trails on steep slopes should have occasional water bars.

(4) Servicing of equipment involving fuel, lubricants, or coolants should be performed in places where these materials cannot enter streams. Spent oil should be collected for proper disposal, never poured on the ground.

(5) Upon completion of logging, erosion-prone areas should be mulched or seeded.

Mechanical Site Preparation

(1) Avoid excessive soil compaction.

(2) Minimize erosion and the movement of sediment into waters.

(3) Prevent accumulation of debris in ponds, streams, or rivers.

(4) Windrows, disking, bedding, and planting with "furrow" type mechanical planters should follow contours.

(5) Avoid complete disking of steep slopes with extremely erodible soil.

(6) Plant trees on contour.

Disposal of Debris and Litter

(1) Logging debris in streams should be removed immediately.

(2) Debris from landings should not be pushed into drains, streams or Streamside Management Zones (SMZs)

(3) All trash associated with the logging operation should be promptly removed (not buried) and hauled to a legal disposal site.

3.0 Silvicultural Chemical Management

Description and Purpose

Pesticides are used on forest lands to facilitate meeting forest management objectives. The purpose of a pesticide application is to rid an area of undesirable vegetation or control insects or diseases to promote the establishment, survival, growth or maintenance of a desired species or condition.

Planning Considerations

Planning is an essential first step in reducing pest problems. A plan is needed by which the application of pesticides is utilized in an efficient manner that produces no adverse impacts on the environment. The maintenance of water quality is an important consideration in all aspects of pesticide operation planning.

Pesticide Selection

When the decision is made to use pesticides, choose products suitable for use on the target species and registered for the intended uses. Use only pesticides registered by the Environmental Protection Agency. Prior to using any pesticide, carefully read and follow all label directions.

When selecting pesticide options, more than effectiveness and cost should be evaluated. Consideration should be given to site factors, application conditions and techniques and products that can influence impacts to water quality.

Three main characteristics can greatly affect a pesticide potential to contaminate surface or ground water. They are solubility, absorption and breakdown rate.

1) Solubility

Solubility is the ability of a pesticide to dissolve in water. The greater the solubility, the greater the chance that the chemical will leach to ground water.

2) Absorption

Absorption is the inherent ability of a pesticide to bind with soil. Some pesticides stick very tightly to soil while others are easily dislodged. A greater absorption means a pesticide will remain longer in the soil and thus be less likely to leach down into the ground water before it has degraded. Absorption increases as soil organic matter increases.

3) Breakdown Rate

Breakdown rate or half-life is the time a pesticide takes to degrade or breakdown into other chemical forms. Pesticides that do not break down quickly can be hazardous if they move to ground water or surface water.

In a given situation, pesticides with the highest water solubilities, greatest persistence, lowest affinities for absorption to organic matter and other soil components, and highest application rates have the greatest potential for movement in surface water or to ground water. An alternative means of minimizing the potential movement of a pesticide is to select a non-broadcast application

technique for the same pesticide that reduces the amount of the chemical applied directly to the soil.

Procedures for Chemical Use

Proper pesticide management practices make efficient use of chemical while preventing contamination of surface water or ground water. Residues of pesticides used in forestry can affect water quality at several phases of the chemical use cycle. These phases are: 1) transportation, 2) storage, 3) mixing and loading, 4) application, and 5) cleanup and disposal. To minimize potential impacts on water quality, use of the following practices is encouraged.

A) Transportation

(1) Inspect all containers prior to loading and ensure all caps, plugs and bungs are tightened.

(2) Handle containers carefully when loading them onto vehicles.

(3) Secure containers properly to prevent shifting during transport.

(4) Check containers periodically enroute.

(5) Limit access to containers during transport to prevent tampering.

(6) Educate and inform the driver of the proper transportation precautions.

(7) Never transport pesticides unless arrangements have been made to receive and store them properly.

B) Storage

(1) Chemicals should be managed and stored in accordance with all applicable federal, state, or local regulations. These would include:

(a) The EPA container registration label, as printed on the label;

(b) Label instruction for use as provided by the manufacturer;

(c) Requirements or the use, application, and registration of pesticides;

(d) Requirements relating to the licensing of applicators.

(2) All containers should be labeled in accordance with applicable federal, state and local regulations.

(3) Apply pesticides under favorable weather conditions. Never apply a pesticide when there is a likelihood of significant drift.

(4) Always use pesticides in accordance with label instruction, and adhere to all Federal and State policies and regulations governing pesticide use.

E) Cleanup and Disposal

(1) Before disposal, containers should be rinsed as described in equipment cleanup.

(2) Cleanup should be in a location where chemicals will not enter any stream, pond, or where stream pollution might occur.

(3) Rinse empty pesticide containers and mixing apparatus as many times as needed. This flushing should be applied in spray form to the treated area, NOT into the ground near streams.

(4) Dispose of pesticide wastes and containers according to federal and state laws. Some pesticide wastes are specifically identified as hazardous wastes by law and must be handled and disposed of in accordance with hazardous waste regulations. For more information about proper management of waste pesticides, contact the Department of Health, Environmental Health Administration.

Other chemicals

Improper storage and handling of oil products and fuel can be a water quality hazard. Improper disposal of oil or fuel can contaminate ground water and seep into streams. The following are recommended:

(1) Locate facilities away from streams and be prepared to clean up spills.

(2) Know and comply with regulations governing the storage, handling, application (including licensing of applicators), and disposal of hazardous substances.

(3) Do not transport, handle, store, load, apply or dispose of any hazardous substance or fertilizer in such a manner as to pollute water supplies or cause damage or injury to land, including humans, desirable plants and animals.

(4) Do not store, mix, or rinse hazardous substances or fertilizers within the streamside management zone or where they might enter streams or waterways.

(5) Develop a contingency plan for hazardous substance spills, including cleanup procedures.

(6) Report all spills to the Department of Health, Environmental Health Administration.

4.0 Streamside Management Zone (SMZ)

The Special Management Zone (SMZ) is a specific area associated with a stream, lake, wetland or other waterbody that is designated and maintained during silviculture operations. The purpose of the SMZ is to protect water quality by reducing or eliminating forestry related ouputs, i.e. sediment, nutrients, logging debris, chemicals, and water temperature fluctuations that can adversely affect aquatic communities. SMZs provide shade, streambank stability and erosion control, as well as detritus and woody debris which benefit the aquatic ecosystem in general. In addition, the SMZ is designed to maintain certain forest attributes that will provide specific wildlife habitat values. Snags, den and cavity trees as well as mast producing trees, left in the SMZ, are necessary to meet habitat requirements for certain wildlife.

The SMZ has specific criteria, that defines operational restrictions and special management objectives. In addition, the SMZ has a specific width which is based on the size and type of waterbody involved.

A Streamside Management Zone (SMZ) is an area covered with vegetation or ground cover on both sides of perennial, intermittent streams and other bodies of open water, where extra precaution is used in carrying out forest management practices. The SMZ also provides shade and functions as a buffer when fertilizers, pesticides, etc. are applied to adjacent lands. For practical purposes, an SMZ must be wide enough to protect water quality and stream characteristics. Precaution is needed in carrying out forest management practices in order to protect bank edges and water quality. Determining the necessary width involves in part a judgement factor based on reliable local experience.

SMZs should be used where: 1) water quality is impaired and adjacent land use contributes to that degradation, 2) good water quality exists and protection against potential future impairment is desired, 3) streambank erosion is a concern, 4) wildlife habitat enhancement is desired, and/or 5) silviculture practices are to be implemented, and 6) the lower edge of cropland, grassland, or forest land is adjacent to permanent or intermittent streams, or border streams, rivers, ponds or intermittent or permanently flooded, open-water wetlands.

SMZ benefits include the following:

(1) Shade - Trees within the SMZs provide shade to maintain cool water temperatures which aid in the spawing of fish. Without trees and overhanging shrubs, stream temperatures would increase during the summer. Some fish species and aquatic organisms would then be unable to live in the streams. In the summer, water from shaded streams eventually flows into larger bodies of water and helps maintain its fish and aquatic life by keeping these waters cool all the way downstream.

(2) Food - Leaves and insects drop into streams from overhanging trees and shrubs. In fact, 90% of the food in the forested streams comes from bordering vegetation.

(3) Protection of Streambanks - Many streambanks are stabilized by streambank trees. They anchor banks and prevent erosion during periods of high water. Removing trees and shrubs and substituting shallow rooted grasses can lead to streambank collapse and stream sediment. Bank overhang is created by stream flows undercutting the stream bank and tree roots. Fish can rest, hide from predators, and feed in these protected areas.

(4) Flooding - Healthy SMZs stabilize floodplains. During times of high water, SMZs reduce the velocity of floodwaters. Their dense vegetation and deep humus slow down racing waters. Forest floodplains suffer less damage when SMZs are protected during harvesting activities.

(5) Recreation - The recreational activities that we enjoy in and around streams are many. This includes swimming, fishing, camping, hunting, and backpacking to name a few.

(6) Timber Production - For those who grow and harvest trees, the fact is that trees often grow best in SMZs. Trees respond to those deep, fertile, and moist soils. Logging activities should not be eliminated within SMZs but modified to insure that stream channels and banks are protected from disturbance. SMZs are not timber harvest "keep out" zones, but there are locations where timber harvesting activities must be modified to protect the many benefits mentioned above.

Recommendations

SMZs should be maintained along all perennial streams or where forest disturbances occur and surface runoff will carry sediment loads. SMZs should be maintained around streams, ponds, perennial flowing natural springs, and all springs and reservoirs serving as domestic water supplies. The following best management practices are recommended:

(1) The width of SMZs should be determined depending on the following conditions: slope of land adjacent to stream, soil erodibility, precipitation, knowledge of particular area, sensitivity of stream, etc. These factors can be obtained from soil maps, on-the-ground evaluation and measurements, weather data, etc.

(2) SMZs should be designed on a case-by-case basis. Most important is that SMZs be consistent with stream characteristics and wide enough to protect water quality.

Soil Type	Percent Slope	SMZ Width (each side)
Slightly erodible	0-5	35'
Slightly erodible	5-20	35-50'
Slightly erodible	20+	50-160'
Erodible	0-5	35-50'
Erodible	5-20	80' minimum
Erodible	20+	160' minimum

Table 1. Recommended Widths for Streamside Management Zone

[NOTE: Please contact your local Natural Resources Conservation Service office to determine the erodibility factor of the soil before determining the proper width of the SMZ.]

(3) On relatively flat terrain (0-5%) on slightly erodible soils, the width of an SMZ should be at least 35 feet wide on each side of a stream.

(4) On relative flat terrain (0-5%) on erodible soils, the SMZ width should range between 35 to 50 feet on each side of a stream.

(5) On slightly erodible soils with slopes ranging between 5 and 20 percent, the SMZ width should range between 35 to 50 feet wide on each side of a stream.

(6) On erodible soils with slopes ranging between 5 and 20 percent, the SMZ width should range between 50 to 160 feet on each side of a stream.

(7) On slightly erodible soils with slopes exceeding 20 percent, the SMZ width should be at least 80 feet on each side of a stream.

(8) On erodible soils with slopes exceeding 20 percent, the SMZ width should be a minimum of 160 feet on each side of a stream.

(9) Partial harvesting is acceptable. A minimum of 50% of the original crown cover or 50 square feet of basal area per acre, evenly distributed, should be retained in the SMZ. This may be adjusted to meet on-site conditions.

(10) Clearcutting is always prohibited within the SMZ.

(11) Designate SMZs to provide stream shading, soil stabilization, sediment and water filtering effects, and wildlife habitat.

(12) Strive to protect the forest floor and understory vegetation from unnecessary damage. Do not remove (harvest) trees from banks, beds or slopes if it will destablilize the soil. Trees on the south and west banks provide the most critical shading of water.

(13) Access roads should cross perennial or intermittent streams at or near a right angle.

(14) Drainage structures such as ditches, cross drain culverts, water bars, rolling dips, and broad-based dips should be used on all roads prior to their entrance into an SMZ to intercept and properly discharge runoff waters.

(15) SMZs may be desirable on intermittent streams for large drainage areas where wildlife is a major landowner concern or for other reasons.

5.0 Fencing

(1) Fencing out livestock, pigs, and other animals in certain areas will help to prevent water quality degradation of streams, protect threatened and endangered plants, reduce soil compaction and maintain soil productivity. Fencing is applicable where desired forest reproduction, soil hydrologic values, existing vegetation, aesthetic values, and recreation are prevented or damaged by these animals.

(2) Pastures should be fenced separately from woodlands. Consider maintenance as well as ease of construction when planning a fence location. By taking advantage of natural barriers such as cliffs, the cost of animal exclusion can be reduced. Also consider use of fences to protect vegetation that provides wildlife food and cover.

(3) Fences should be permanent stock fences built in accordance with good construction principles and workmanship.

6.0 Wildfire Damage Control and Reclamation/Prescribed Burn

The prevention, control, and extinguishment of all wildfires on grass, brush, and watershed lands and the implementation of a prescribed fire program is a desirable goal. Where wildfires do occur, the first and foremost concern is to control the fire and limit the damage. Fire suppression activities can add to the problem of water quality protection.

The loss of vegetative cover, destruction of soil-holding feature of root masses, the exposure of bare mineral soil, is a combination that makes the area burned a highly erodible one. The effects of suppression efforts and equipment operations necessary to control and stop the fire can magnify the erosion problem.

The following are best management practices for wildfire control and reclamation:

(1) The first and foremost concern in wildfire control is to prevent harm or damage to people and property. Fireline best management practices should incorporate minimum impact strategies, which meet land and resource management objectives;

(2) Areas with bare mineral soils should be revegetated and areas where vegetative cover has been killed or severely degraded should be regenerated with plant species appropriate for the soil conditions;

(3) First priority for revegetation/reforestation should be given to banks of surface water bodies so that the SMZ is reestablished;

(4) Firelines should be stabilized and, if necessary, revegetated. Erodible areas altered by suppression equipment activities should be repaired and revegetated as necessary;

(5) Access road surfaces should be repaired and stabilized as necessary.

(6) Whenever possible, avoid using fire suppression chemicals over watercourses and prevent their runoff into watercourses. Do not clean application equipment in watercourses or locations that drain into watercourses.

(7) Provide advance planning and training for firefighters that considers water quality impacts when fighting wildfires. This can include increasing awareness so direct application of fire suppression chemicals to waterbodies is avoided and firelines are appropriately placed.

(8) Include rehabilitative practices as part of suppression and post-suppression tactics and strategies to mitigate non-point source pollution.

6.1 Fireline Construction and Maintenance

Fireline construction and maintenance is an essential part of forest and other land management activities. It deals with site preparation burning, prescribed burning, and wildfire defense and control. A number of control practices can be implemented during fireline construction to prevent unnecessary erosion. Periodic inspection and proper maintenance can prevent potential erosion on established firelanes. The following are best management practices for fireline construction and maintenance:

(1) Firelines should be constructed on the perimeter of the burn area and along the boundary of the Streamside Management Zone. The purpose of protecting the Streamside Management Zone from fire is to safeguard the filtering effects of the litter and organic matter;

(2) Firelines should follow the guidelines established for logging trails and skid trails with respect to waterbars and wing ditches, and should be only as wide and as deep needed to permit safe prescribed burns or fire suppression needs;

(3) Firelines which would cross a drainage should be turned parallel to the stream or have a wing ditch or other structure allowing runoff in the line to be dispersed rather than channeled directly into the stream.

(4) All firelines should be assessed after the fire is controlled for appropriate stabilization, and if necessary, proper rehabilitation should be done while equipment and people are in place.

6.2 Prescribed Burn

(1) Intense prescribed fire for site preparation shall be conducted only if it achieves desired results with minimum impacts to water quality.

(2) Burning on steep slopes or highly erodible soils should be conducted when they are absolutely necessary and should follow carefully planned prescriptions.

(3) Carefully plan burning to adhere to time of year, weather, topography, and fuel conditions that will help achieve the desired results and minimize impacts on water quality. With proper planning, prescribed fires should not cause excessive sedimentation due to the combined effect of removal of canopy species and the loss of soil-binding ability of the subcanopy and herbaceous vegetation roots, in streamside vegetation, small ephemeral drainages, or on very steep slopes.

(4) Site preparation burning creates the potential for soil movement. Burning in the SMZ reduces the filtering capacity of the litter. All efforts should be made to plan burns to minimize impacts on the SMZ.

(5) All bladed firelines, for prescribed fire and wildfire activities, should be built so as to minimize erosion. If necessary, the firelines should be stabilized with water bars and/or other appropriate techniques to control excessive sedimentation or erosion of the fireline. Include any erosion control practices in the construction of firelines.

7.0 Reforestation

Reforestation refers to those operations undertaken to establish a new forest. Site preparation, for the purpose of forest regeneration, is a basic silvicultural tool where for competing vegetation and

reduction of logging debris are necessary. Common site preparation techniques include, manual, mechanical, fire, and herbicides.

Regeneration includes hand and machine planting and direct seeding. Since hand planting and direct seeding pose no water quality problems, BMPs are not necessary. Some mineral soil exposure does occur with machine planting and BMPs are offered.

1) Sites should receive the minimum preparation necessary to successfully control competing vegetation and establish a desirable timber stand. In general, the more intensive the treatment, the more concern for water quality.

2) When working on slopes, mechanical operations such as ripping, shearing, etc., should follow contours.

3) Hand planting, direct seeding or natural regeneration should be used on protected areas adjacent to streams or on slopes too steep to machine plant.

APPENDICES

1. Definition of Terms
2. Road Construction Applications
3. Streamside Management Zone
4. Available Assistance
5. Suggested Readings

definition of terms

DEFINITION of TERMS:

Best Management Practices -- effective, practical, structural or nonstructural methods which prevent or reduce the movement of sediment, nutrients, pesticides and other pollutants from the land to surface or ground water, or which otherwise protect water quality from potential adverse effects of silvicultural activities. These practices are developed to achieve a balance between water quality protection and the production of wood crops within natural and economic limitations.

Bucking -- to saw felled trees into predetermined lengths.

Clearcutting -- the removal of all standing trees within a designated area.

Cross drain -- a cross ditch used to move water from one side of the road to the other side to prevent accumulation of runoff without the need of a culvert or bridge.

Culvert -- a conduit through which surface water can flow under roads.

Diversion ditch - a ditch built across the top of a slope to divert surface water from that slope.

Felling -- the process of severing trees from stumps.

Firebreaks -- naturally occurring or man-made barriers preventing the spread of fire.

Fireline construction -- the construction of a barrier used to prevent the spread of fire.

Intermittent streams -- streams that provide water flow continuously during some seasons of the year but little or no flow during the remainder of the year.

Landing -- an area in the field where logs are collected.

Non-point source -- a source of water pollution which are induced by natural processes, including precipitation, seepage, percolation, and runoff; and not traceable to any discrete or identifiable source.

Perennial streams -- streams which provides water flow at all times except during extreme drought.

Pesticides -- any herbicide, insecticide, or rodenticide, but does not include non-toxic repellents or other chemicals.

Pre-commercial thinning - the removal of selected trees within an established forest destined for commercial use.

Prescribed burning -- the controlled application of fire as a management tool in forest management.

Reforestation -- the successful reestablishment of tree species following harvest.

Silvicultural practices -- all forest management practices, including the establishment, composition, constitution, and growth of forests.

Site preparation -- the removal of unwanted vegetation and other material prior to reforestation.

Skid trails -- routes over which logs are moved to a landing or road.

Streamside Management Zone -- an area on each side of the banks and above the head of intermittent streams, perennial streams, and other drains or bodies of water where extra precaution in carrying out best management practices is needed to protect bank edges and water quality.

Waterbar -- a cross drainage diversion ditch and/or hump in a trail or road for the purpose of diverting surface water runoff into roadside vegetation, duff, ditch, or dispersion area to minimize the volume and velocity which can cause soil movement and erosion.

Wetlands -- geographic areas that are inundated or saturated by surface or groundwater at a frequency or duration sufficient to support (and under normal circumstances do support) a prevalence of vegetation typically adapted for life in saturated soil conditions.

Wing ditch -- a water turnout or diversion ditch constructed to move and disperse water away from the road and side ditches into adjacent undisturbed areas so that the volume and velocity of water is reduce on slopes.

Yarding -- the method of log transport from the harvest area to the storage area.

BROAD BASED DIPS

Definition:

A dip and reverse slope in a truck road surface with an outslope in the dip for natural cross drainage.

Purpose:

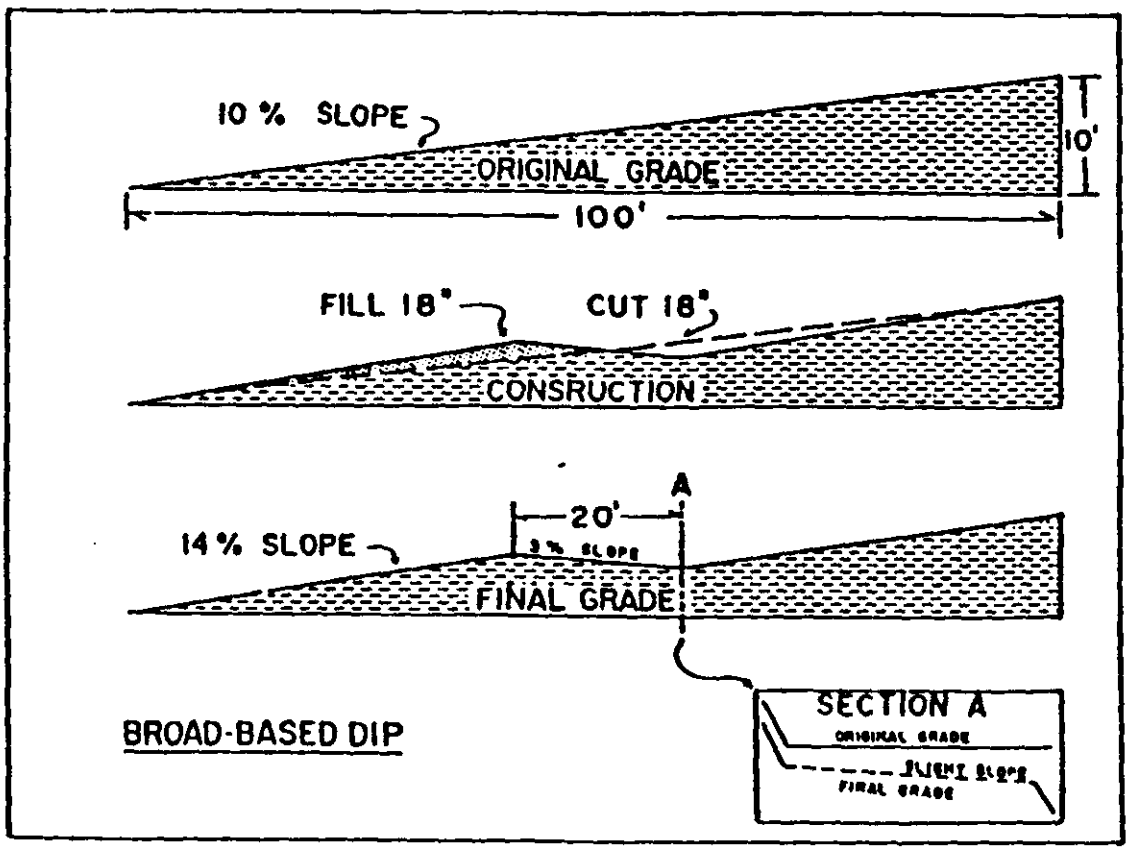
To provide cross drainage on insloped truck roads to prevent build-up of excessive surface runoff and subsequent erosion.

Conditions Where Practice Applies:

Use on truck roads and heavily used skid trails having a gradient of 10% or less. May be substituted for other cross drainage structures where no intermittent or permanent streams are present.

Guidelines:

* Proper construction requires an experienced bulldozer operator.
* Installed after the basic roadbed has been constructed and before major hauling use.



- On grades steeper than 8%, surface dips with stone (approx. 3" diameter) or gravel.
- Use dips on approaches to steep declines in heavily used skid trails.
- Discharge area should be protected with stone, grass sod, heavy litter cover or slash and logs to reduce the velocity and filter the water.

SPACING FOR BROAD BASED DIPS

Road Grade (percent)	Spacing Between Dips (feet)
2	300
4	200
6	165
8	150
10	140
12	130

WATER BARS

Definition:

An earthen or reinforced berm constructed across a truck road or skid trail.

Purpose:

To intercept and divert water from side ditches and truck road or skid trail surfaces, therefore minimizing erosion by decreasing the slope length of surface water flow.

Conditions Where Practice Applies:

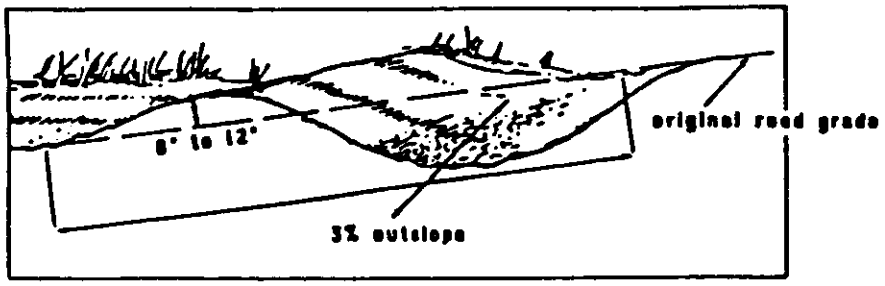
Utilized on any sloping truck road or skid trail where surface water runoff may cause erosion.

Guidelines:

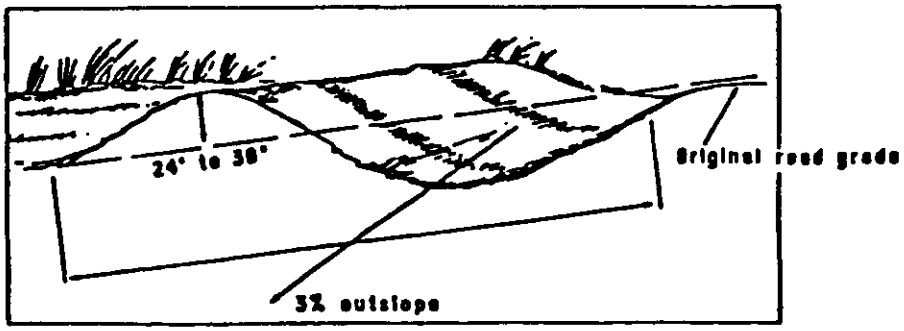
* Start placement of water bars at the farthest skid trail and work back to the log landing and then to the truck road.
* Install water bars with a skidder blade, dozer blade, or by hand.
* Install water bars at the top of any sloping road or trail and at proper spacing along steep sections.

* Water bars may be shallow or deep depending on the need.
* Soil should be left along the lower side of the water bar.
* Should be constructed at a 30° - 35° angle downslope from a line perpendicular to the direction of the truck road or skid trail.
* Should drain at a 3% outslope onto undisturbed litter or vegetation.
* The uphill end of the water bar should extend beyond the side ditch line of the road or trail to fully intercept any water flow.
* The downhill end of the water bar should be fully open and extended far enough beyond the edge of the road or trail to disperse runoff water onto undisturbed forest floor.
* Place rocks, slash, or logs to disperse water coming from a water bar.
* If the road or trail is to be kept open after the harvesting operation, the following guidelines should be used in order to preserve effective water bars.
    - Reinforce the water bars
    - Keep travel to a minimum
    - Use only in dry weather
    - Make frequent inspections
    - Maintain as needed

SHALLOW WATER BAR



DEEP WATER BAR



SPACING FOR WATER BARS

Road/Trail Grade (percent)	Spacing Between Water Bars (feet)
2	250
5	135
10	80
15	60
20	45
30	35

CROSS DRAINAGE CULVERTS

Definition:

Corrugated pipe, well casing, dredge pipe, or other suitable material placed under a truck haul road or major skid road to transmit ditch runoff and seeps from a drainage area of less than 10 acres.

Purpose:

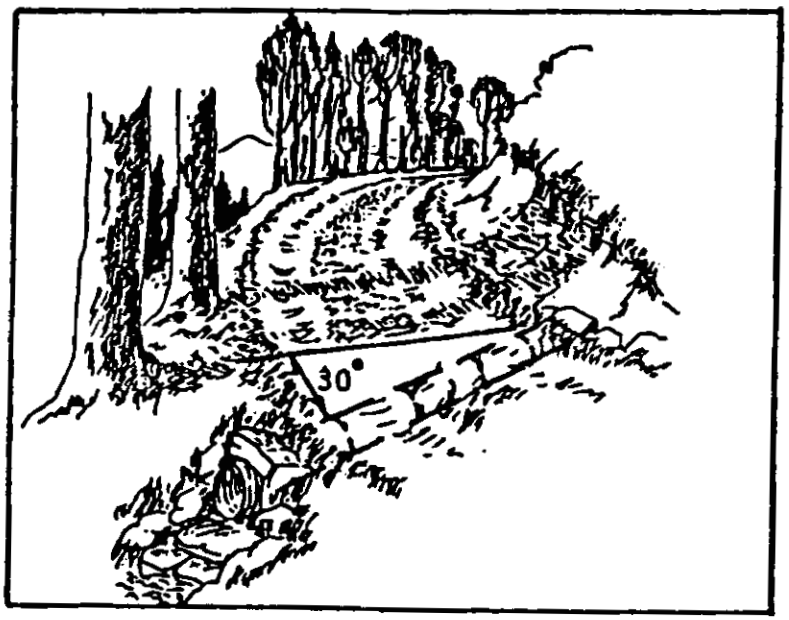
To collect and transmit water flows from side ditches and seeps, under truck haul roads and major skid trails safely without eroding a drainage system or road surface.

Conditions Where Practice Applies:

For any size operation where cross drainage of storm water is required temporarily or permanently.

Guidelines:

* This is the most expensive method of road cross drainage and should be used where heavy road use is anticipated during and after the harvesting operation.



* When sizing culverts for temporary roads, allow for periods of high flow, such as spring runoff or cloudbursts.

* The minimum size culvert to be installed is 12 inch diameter and 20 feet in length.

- When constructing roads on sidehill locations, ditch uphill side of the roadway to intercept surface runoff.

- Allow inlet end of culvert to extend into side ditch so that it intercepts water flowing in the ditch. Construct a berm across the side ditch to assist in diverting water into the culvert.

- Allow outlet end of culvert to extend beyond any fill and empty onto an apron of rock, gravel or logs.

- Space culverts according to road grade:

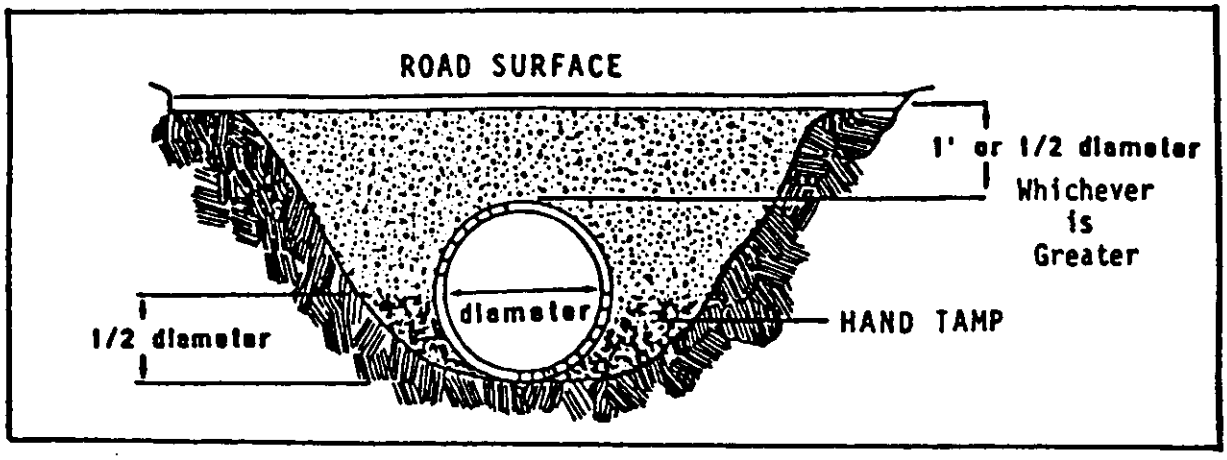
On gentle slopes (1-2%)	300 feet
On moderate slopes (3-10%)	150 feet
On steep slopes (10%+)	100 feet or less

- Culverts should be installed at a 30-35 degree angle downgrade.

- Culverts should be sloped at least 5 inches for every 10 feet of length to permit self-cleaning.

- When harvesting operation has been completed, the road should be stabilized by installing water bars and removing all pipe culverts from truck roads which will not be maintained.

- Culverts, when not maintained, are very likely to become blocked with rocks, ice or other debris. Runoff water can become rerouted over and around the culvert and may wash out sections of road into brooks, streams, ponds or wetlands. It is important to clean culverts regularly. Check after every storm.



- Culvert size selection should be based on the size of the drainage area of a forested watershed and should be able to handle the largest flows.

- Estimating drainage area by taking measurements on a USGS topographic map, using contour lines to define the drainage limits. The Soil Conservation Service can assist you with determination of drainage area.

OPEN TOP CULVERTS

Definition:

A wooden culvert placed across truck haul roads to convey surface runoff and side ditch flows across to downslope side.

Purpose:

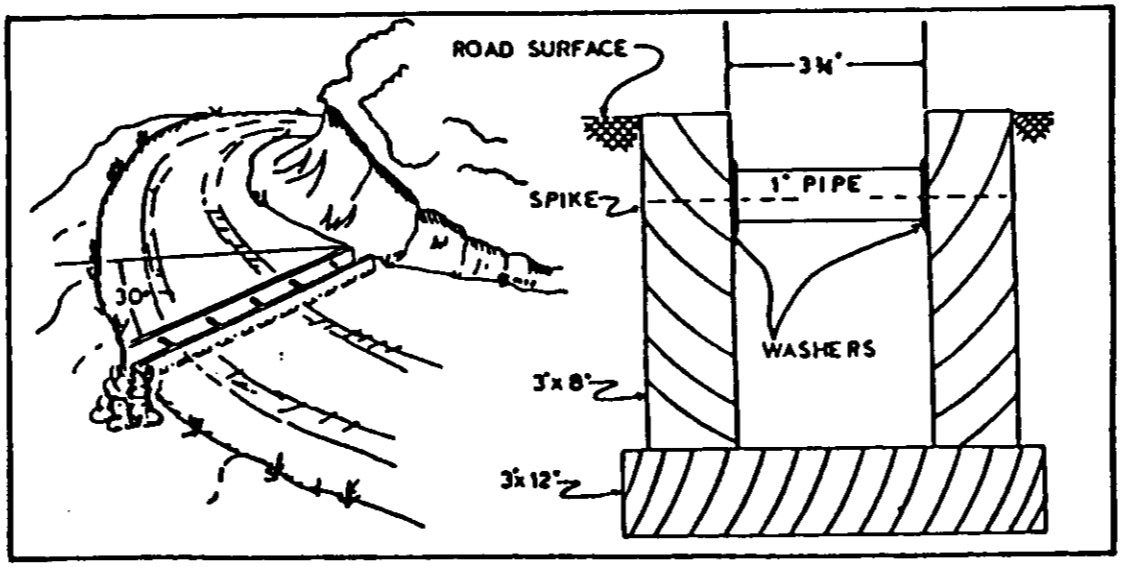
To collect and direct road surface storm runoff and upslope side ditch flows across road without eroding drainage system or road surfaces.

Conditions Where Practice Applies:

This is a temporary drainage structure for on-going harvesting operations. Property built and maintained, it can be used for cross drainage on roads of smaller operations as a substitute for a pipe culvert. This practice should not be used for handling intermittent or live streams or skid trail cross drainage.

Guidelines:

* Can be constructed of cull logs or from sawn lumber. If made of durable wood or treated material, these culverts will give many years of service.



- To be installed flush with the road surface and skewed at an angle not less than 30 degrees downgrade.
- Allow the inlet end to extend into the cut slope or side ditch so that it intercepts water.
- Allow outlet end to extend beyond any fill and empty onto an apron of rock, gravel or logs.
- Open top culverts must be cleaned regularly to remove sediments, gravel, and logging debris to allow normal function of structure at all times.

SPACING FOR OPEN TOP CULVERTS

Road Grade (percent)	Spacing Between Culverts (feet)
2	300
4	200
6	165
8	150
10	140
12	130

road construction applications

OUTSLOPING

Definition:

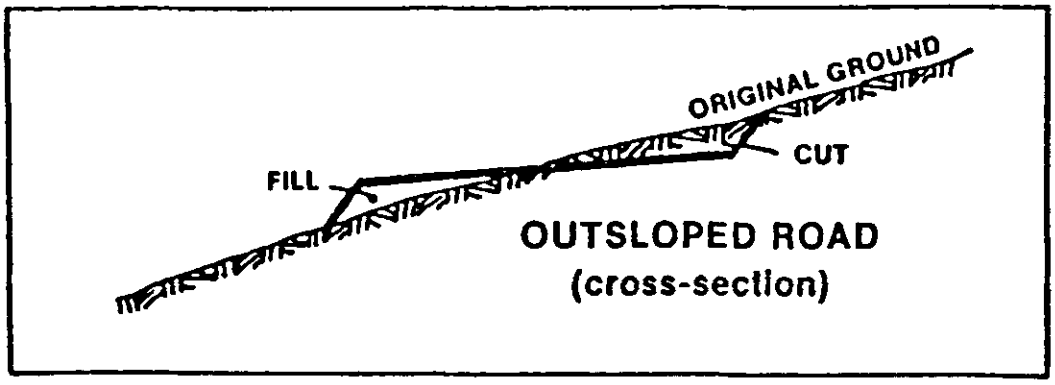
A section of road is sloped slightly (1-3%) from the cut bank to the outside edge of the road bed.

Purpose:

Effective way of limiting erosion because water is removed from the road surface quickly and diverted on to the forest floor.

Condition Where Practice Applies:

Used when the area is entirely rock, or when water can be diverted on to undisturbed forest floor.



INSLOPING

Definition:

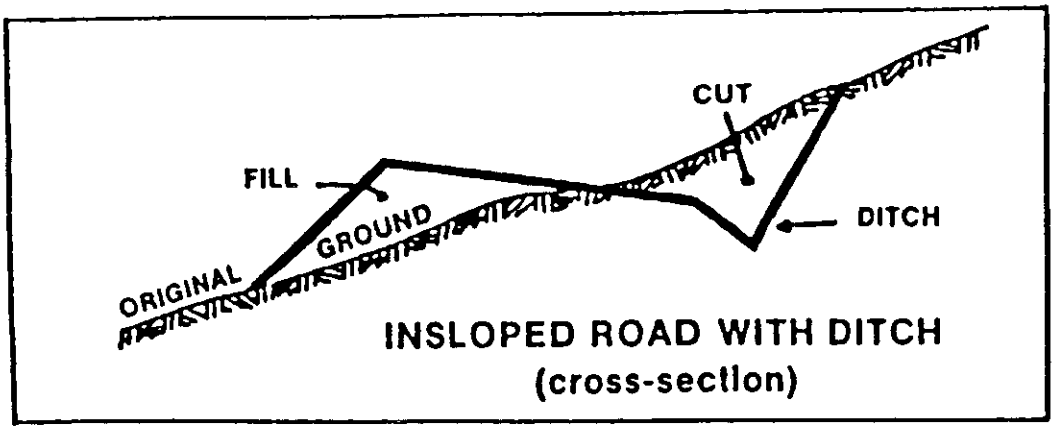
A section of road is sloped slightly (1-3%) toward the cut bank.

Purpose:

Effective way of limiting erosion because water is removed from the road surface quickly and diverted directly to the inside ditch which will carry the water into a culvert.

Condition Where Practice Applies:

Used when the soils are easily saturated or highly erodible. This will limit the amount of ditch water which will flow on to unstable fills.



CROWNING

Definition:

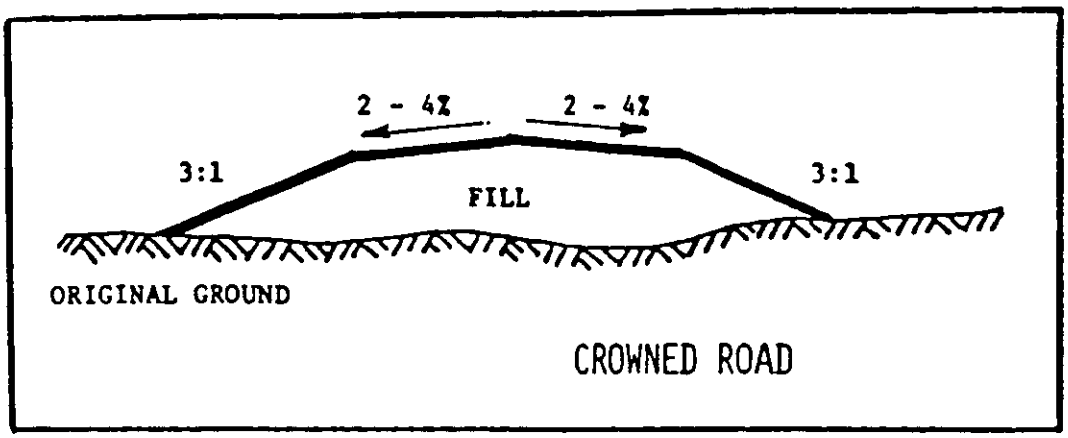
A section of road is sloped slightly (2-4%) from the center line of the road to the outside edges of the roadbed.

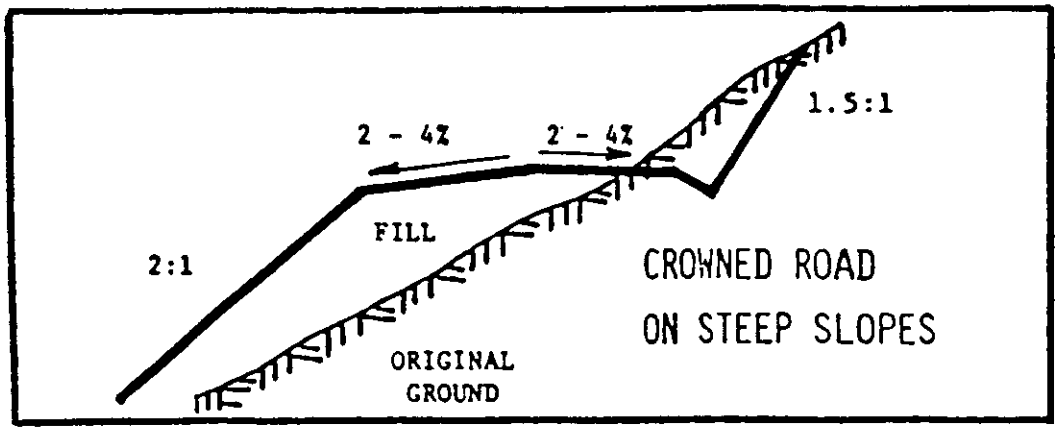
Purpose:

Effective way of limiting erosion because water is removed from the road surface quickly and diverted directly onto the forest floor or into a ditch which will carry the water into a culvert.

Conditions Where Practice Applies:

Used when soils are easily saturated or highly erodible when adjacent areas are relatively level with roadbed or on steep side hills.





streamside management zone

STREAMSIDE MANAGEMENT ZONE

Streamside Management Zones (SMZs) should be maintained along all perennial streams or where forest disturbances occur and surface runoff will carry sediment loads. SMZs should be maintained around streams, ponds, perennial flowing natural springs, and all springs and reservoirs serving as domestic water supplies.

The width of SMZs should be varied, depending on the following conditions: slope of land adjacent to stream, soil erodibility, precipitation, knowledge of particular area, sensitivity of stream, etc. These factors can be obtained from soil maps, on-the-ground evaluation and measurements, weather data, etc.

SMZs should be designed on a case-by-case basis. Most important is that SMZs be consistent with stream characteristics and wide enough to protect water quality.

The following is offered as a guideline:

Soil Type	Percent Slope	SMZ Width (each side)
Slightly erodible	0-5	35'
Slightly erodible	5-20	35-50'
Slightly erodible	20+	50-160'
Erodible	0-5	35-50'
Erodible	5-20	80' minimum
Erodible	20+	160' minimum

[NOTE: Please contact your local Natural Resources Conservation Service office to determine the erodibility factor of the soil before determining the proper width of the SMZ.]

available assistance

Available Assistance

Department of Land & Natural Resources
Division of Forestry and Wildlife
1151 Punchbowl Street, Room 325
Honolulu, HI 96813
Telephone: (808) 587-0166 Facsimile: (808) 587-0160

Hawaii Branch

P.O. Box 4849
Hilo, HI 96720-0849
Telephone: (808) 974-4221
Facsimile: (808) 974-4226

Maui Branch

54 High Street
Wailuku, Hi 96793
Telephone: (808) 984-8100
Facsimile: (808) 984-8111

Oahu Branch

2135 Makiki Heights Drive
Honolulu, HI 96822
Telephone: (808) 973-9778
Facsimile: (808) 973-9781

Kauai Branch

3060 Eiwa Street, Rm. 306
Lihue, HI 96766-1875
Telephone: (808) 274-3433
Facsimile: (808) 274-3438

Natural Resources Conservation Service
Prince Kuhio Federal Bldg., Rm 4-118
Honolulu, HI 96850
Telephone: (808) 541-2600

Hawaii District Offices

Hilo Office
154 Waianuenue Avenue
Hilo, HI 96720
Telephone: (808) 961-5502

Kealakekua Office
P.O. Box 636
Kealakekua, HI 96750
Telephone: (808) 322-2484

Kamuela Office
P.O. Box 1089
Kamuela, HI 96743
Telephone: (808) 885-6602

Pahala Office
P.O. Box 807
Pahala, HI 96777
Telephone: (808) 928-6185

Natural Resources Conservation Service, cont'd.

Maui District Offices

Wailuku Office
70 S. High Street
Wailuku, HI 96793
Telephone: (808) 2444-3729

Molokai Office
P.O. Box 376
Kaunakakai, HI 96748
Telephone: (808) 567-6530

Kauai District Office

Lihue Office
4334 Rice Street, Rm. 104
Lihue, HI 96766
Telephone: (808) 245-6513

Consulting Foresters

Contact the Division of Forestry and Wildlife at (808) 587-0166 for the latest list.

NOTES

Suggested Readings

1. "Logging Roads and Skid Trails, A Guide for Soil Protection and Timber Access," Indiana Department of Natural Resources - Division of Forestry, 21 pp.

2. Dellberg, Robert A., "Road Building for Small Private Roads," Mendocino County Resource Conservation District, Ukiah, CA., July 1992, 73 pp.

3. Walbridge, T.A. Jr., "The Direct Location of Forest Roads," Virginia Polytechnic and State University, Blacksburg, VA., 1990, 70 pp.

4. Walbridge, T.A. Jr., "The Paper Location of Forest Roads," Virginia Polytechnic and State University, Blacksburg, VA., 1990, 75 pp.

5. Walbridge, T.A. Jr., "Field Tables for the Direct Location of Forest Roads," Virginia Polytechnic and State University, Blacksburg, VA., 1991, 15 pp.

6. Wenger, Karl F., "Forestry Handbook, Second Edition," Society of American Foresters, 1984, 1,335 pp.

7. "Erosion and Sediment Control Guide for Hawaii," Soil Conservation Service, 1981, 178 pp.

Forest Management Plan

Kaupakuea Orchards, LLC

April 22nd, 2013

Prepared by
Thomas Baribault, Ph.D., Research Forester

Forest Solutions Inc.

I. Applicant and property information

1.1 Applicant

Name:	Christopher Trimarco
Address:	4110 NE 27th Avenue
	Lighthouse Point, FL 33064
Email:	christophertrimarco@mac.com
Phone:	+1 (954) 650-0967
Fax:	NA
TMK number:	(3)2-8-003-009; (3)2-8-003-010
State and County Zoning:	Ag 20 (Agricultural District) (Map 1)
Total property acreage:	41.5 acres (Map 2)
Proposed stewardship area:	23.27 acres (Map 2)
Elevational range:	1300 ft (400m) – 1400 ft (430m) ASL
Slope:	≤ 5 %
Streams, gulches:	Waiaʻama Stream (South boundary)
	Ālia Stream (North boundary)

1.2 Consultant

Company:	Forest Solutions, Inc.
Name:	Thomas Baribault
Title:	Research Forester
Address:	P.O. Box 2037
	Kamuela, HI 96743
Email:	tom@hawaiiforest.com
Phone number:	+1 (808) 776-9900 x238
Fax:	+1 (808) 776-9901
Plan completion date:	April 8, 2013

II. Forest Stewardship Plan Signature Page

2.1 Professional Resource Consultant Certification:

I have prepared (or revised) this Forest Stewardship Plan. Resource professionals have been consulted and/or provided input as appropriate during the preparation of this plan.

Prepared by: Forest Solutions, Inc.

Professional Resource Consultant's Signature/Date:_____

Professional Resource Consultant's Name: Thomas Baribault

2.2 Applicant Certification:

I have reviewed this Forest Stewardship Plan and hereby certify that I concur with the recommendations contained within. I agree that resource management activities implemented on the lands described shall be done so in a manner consistent with the practices recommended herein.

Prepared for: Christopher Trimarco

Applicant's Signature/Date:_____

Applicant's Name: Christopher Trimarco

2.3 State Forester's Approval:

This plan meets the criteria established for Forest Stewardship Plans by Hawaii's Forest Stewardship Advisory Committee. The practices recommended in the plan are eligible for funding according to state of Hawai'i Forest Stewardship Program guidelines and administrative rules.

Approved by:_____

State Forester's Signature/ Date:_____

State Forester's Name:_____

2.4 Forest Stewardship Advisory Committee

Approved by:_____

Committee Signature/Date:_____

Printed Name:_____

Table of Contents

III. Introduction

3.1 Land Use History

In pre-contact Hawaii, this mauka area would likely have been reserved for gathering practices, exploiting such resources as wood, medicinal or ceremonial understory plants, or feathers. In approximately 1899, Pepeekeo Sugar Company began commercial production, which continued through the early 1990's. The property was owned by Hāmākua Sugar until 1994; conventional sugar cultivation methods were practiced, including subsoil ripping, irrigation, heavy fertilizer and agrochemical use, and controlled burning. These practices implemented over 95 years led to substantial net losses in soil depth and organic matter, and increased compaction. Thereafter, ownership transferred to a private individual, who leased small portions of the property to rotating ginger producers, alternating with ranching, which continues to the present. The larger original property has been subdivided into the Tax Map Key (TMK) featured in this Forest Management Plan (FMP), and the current owner plans to transition from a largely herbaceous vegetation type to a mixture of tree species within the project area.

3.2 Current Forest Condition

The property is typical of abandoned cane land in the Hilo-Honomu area, with only a small minority of the property (2.8 acres, or 7%) currently forested. The forest area is restricted to less than four acres within the larger Streamside Management Zone (SMZ) adjacent to Waiaʻama Stream, with less than an acre of tree cover elsewhere. Native overstory tree species are a minor component of the SMZ, and the only Hawaiian species present is ʻōhiʻa (*Metrosideros polymorpha*). Several native understory species, chiefly ferns, appear in low numbers among the dominant invasive weed species, which is strawberry guava (*Psidium cattleianum*). An assortment of other weed species are represented to varying degrees, and the pasture area should be considered a completely alien ecosystem dominated by African grasses and assorted broadleaf species. In its current condition, the parcel cannot serve as habitat for any native Hawaiian bird species, or for the Hawaiian bat, all of which require closed canopy forest.

3.3 Management Objectives

Several concurrent management objectives will be pursued on the parcel, including high value hardwood plantations, riparian native species restoration, fruit orchard establishment, and pasture. This FMP is chiefly concerned with the first two objectives (Map 3):

- Restore forest cover to the upper elevations of each TMK by establishing plantations of several high value hardwood species.
- Protect and expand the existing native forest cover in SMZ by controlling invasive weed species.
- Restore portions of the SMZ where invasive species have dominated the ecosystem.
- Provide long-term financial returns through periodic selection harvests of non-native timber plantations.

The long term goals for this FMP are twofold. First, the project will convert more than 23 acres of marginal pasture land to high value hardwood plantations that can be selection harvested on a 40- to 45-year rotation. Second, invasive species in the SMZ, particularly adjacent to Waiaʻama Stream, will be removed and the area restored to a native forest state dominated by ʻōhiʻa in the canopy and native ferns such as uluhe (*Dicranopteris linearis*) and hapuʻu (*Cibotium glaucum*) in the understory. **The landowner intends to support this important work with a combination of federal (e.g. EQIP) and State of Hawaiʻi forest stewardship cost sharing programs.**

IV. Property Description

4.1 Existing vegetation cover (Map 3)

4.1.1 Pasture

The vast majority (37.2 acres, 93%) of the area on the property is currently active pasture land (**Fig. 4.1.1**). In the future, intensive pasture will be discontinued on at least 17 acres and likely across the entire parcel. Although the current vegetation cover consists of almost exclusively grasses, without grazing pressure, a suite of non-native woody species would begin to invade. The most likely invaders include common guava (*Psidium guajava*), strawberry guava (*Psidium cattleianum*), faya tree (*Morella faya*), African olive (*Olea europaea subsp.* Cuspidate), tropical ash (*Fraxinus uhdei*), Albizia (*Albizia lebbeck* and *Falcataria moluccana*), and ginger (*Hedychium spp*) (**Fig. 4.1.1**).

Figure 4.1.1. **Grazing pressure maintained almost completely open land on much of the parcel (top)**. Regeneration of woody species (bottom) would accelerate without the presence of grazing animals.

4.1.2 Overstory

The property supports very limited canopy cover in the SMZ, comprising almost exclusively guava (*Psidium guajava* and *P. cattleianum*) that reach a maximum height of less than 10 m (**Fig. 4.1.2**). A few specimens of ʻōhiʻa (*Metrosideros polymorpha*) are present in the Southern SMZ, with several individuals approximately 15 m tall. Also in the Southern SMZ are several areas that contain dead rose apple (*Syzygium jambos*) that was killed after infection with the Myrtaceae generalist rust *Puccinia psidii*. Counter-intuitively, *Psidium spp* are unaffected by *P. psidii*, and are the chief species that appear to be replacing *S. jambos* in the canopy (**Fig. 4.1.2**). Some seedlings of *F. uhdei* have also escaped from the adjacent State land; these individuals are still juveniles, yet will need to be removed to ensure taxonomic integrity of the SMZ.

Figure 4.1.2. **Canopy trees are primarily *Psidium* species (top left), with a small contingent of the native ʻōhiʻa (top right)**. *Psidium* is replacing *S. jambos* as a consequence of fungal pathogen attack (bottom).

4.1.3 Understory

The understory of the SMZ property is invaded with smaller strawberry guava almost to the exclusion of native species. Several species of ginger (*Hedychium spp.*) and raspberry (*Rubus spp*) are also present, but grazing has controlled these species to a large extent. In limited sections of the Southern SMZ, dense mats of the Hawaiian native uluhe fern have managed to suppress strawberry guava; unfortunately, this dynamic is a losing battle for the uluhe. The native hapuʻu fern (*C. glaucum*) is in the process of being out competed by the guavas (**Fig. 4.1.3**).

Figure 4.1.3. **Grazing has controlled ginger and raspberry (top)**. Aggressive competition from guava species has almost eliminated the hapuʻu fern from the SMZ understory (bottom).

4.2 Forest health

4.2.1 Invasive species

Forest health, such as exists on the property, is exceedingly poor due to the majority component of non-native weed species. Strawberry guava in particular is antithetical to long term forest health, and will universally replace native trees without management intervention. In every respect, the forest management activities proposed in this FMP will lead to quantitative and qualitative improvements in forest health metrics.

4.2.2 Fire risk

The property is moist year round, with rainfall in excess of 150 inches evenly distributed throughout the year (**Map 1, Fig. 4.4.1**). Consequently, fire risk is low, and is not expected to pose a threat to the forest investment or to the restoration effort. Furthermore, the streams that define the North and South boundaries (**Map 2**) provide sources of fire fighting water, while the road at the Eastern edge of the timber compartments (**Map 3**) serves as a fire break. At the Western edge of the property, open pasture is unlikely to carry any significant fire risk. Thickets of uluhe fern may carry fire in the event of extremely dry and windy conditions that prevail for extended periods, however the total area occupied by uluhe is negligible, and all of this area is adjacent to Waiaʻama Stream.

4.2.2 Pests and pathogens

The most significant pathogenic threats to forest health in the Hilo area are fungal agents. In particular, the genera *Fusarium* and *Puccinia* kill the invasive species rose apple (*S. jambos*) may threaten the congeneric ʻōhiʻa as well. ʻōhiʻa is somewhat resistant to the pathogen, so it is still recommended for restoration planting. Another fungal pest is the koa wilt *Fusarium oxysporum*, although the Hawaiʻi Agricultural Research Center (HARC) is actively developing potentially wild-resistant koa varieties, which would be targeted for planting on an experimental basis as

they become available. A timely alternative to resistant koa may be to use seeds from trees adjacent to the property, which through the very fact of their survival have demonstrated some ability to resist wilt, either based on phenotype or pathogen escape. As a consequence of possible wilt damage and no suitably resistant seedling stock, koa remains an experimental component of this FMP.

4.3 Soils

4.3.1 Classification

A single main soil class, the Kaiwiki hydrous silty clay loam, is represented across the property. A precise description of this soil is derived verbatim from the USDA NRCS Soils Data Viewer, 2011:

> *The Kaiwiki hydrous silty clay loam component makes up 90 percent of the map unit. Slopes are 5 to 15 percent. This component is on ash fields on lava flows on shield volcanoes on islands. The parent material consists of volcanic ash. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is very high. Shrink-swell potential is very high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 12 percent. This component is in the F159AY500HI Acacia koa-Metrosideros polymorpha-cibotium Menziesii/freycinetia Arborea ecological site (**Appendix A**). Non irrigated land capability classification is 4e. Irrigated land capability classification is 43. This soil does not meet hydric criteria.*

4.3.2 Description

Due to a prolonged history of heavy land use by sugar cultivation and rotational ginger production, and continued issues with soil compaction and erosion as a consequence of cattle grazing activities, the soil on the property is marginally productive. There has been some surface erosion due to slope, high rainfall and cattle activity, though this is concentrated along pathways and access roads, and the minor SMZ on the Northern drainage.

Taxonomic class: Kaiwiki hydrous silty clay loam

Geographic setting: The Kaiwiki soils are on windward mountain slopes with an Eastern aspect. Elevations range from 1,300 to 1,400 feet, and slopes are 0 to 10 percent. The soils formed in volcanic ash. The average January temperature is 66 degrees F.; the average July temperature is 75 degrees F.; and the mean annual soil temperature is 62 degrees F.

Drainage and permeability: Well drained (**Map 4**); slow runoff; rapid permeability.

4.3.3 Geochemistry

The chemical and physical properties of the soils that dominate the parcel are typical of the Hilo area. In particular, the soils are acidic, with pH (as tested in a water suspension) between 5.3 and 5.7 (**Map 5**). The species selected for planting in this FMP (§5.6) all tolerate some degree of substrate acidity. One constraint to tree growth is the relatively limited amount of solar radiation that reaches the ground. The orographic effect produces significant cloud cover, constraining the area to the lowest productivity class on Hawai‘i Island in spite of its tropical latitude (**Map 6**).

4.4 Water resources

4.4.1 Rainfall

Average annual rainfall for the property reaches 155 inches (3940 mm) per year, with no pronounced dry period. Heavier rainfall concentrated between November and April, with marginally drier summers (**Fig. 4.4.1**). Based on this information, planting activities should be targeted for winter to early spring, while weed control and other preparation and maintenance should be completed between July and September.

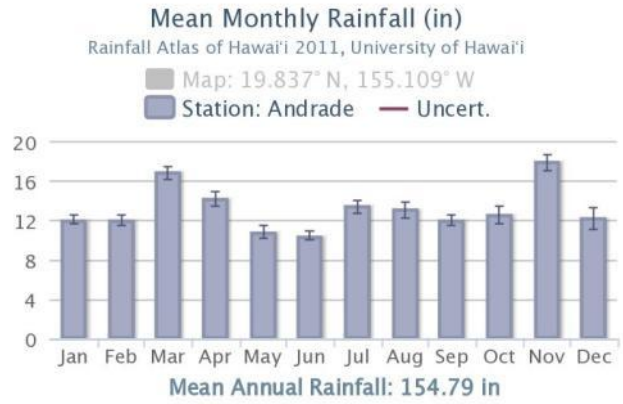


Figure 4.4.1. **Mean annual rainfall for the area surrounding the property**[1].

4.4.2 Streams

One continuous stream (the Waia'ama Stream) defines the Southern boundary of the property, while an intermittent stream (the Ālia Stream) is located at the Northern boundary (**Map 2**). In the center of the Northern parcel is an intermittent drainage bridged by a large concrete box culvert constructed in 1925 (§4.10).

4.4.3 Wetlands

Portions of each TMK contain low areas in which water may collect during heavy rains, but these areas do not qualify as streams or wetlands. Technically and functionally there are no wetlands on the property. The slope of the property and steep banks on streams and intermittent drainages prevent water accumulation.

4.5 Historical or cultural resources

Aside from the 1925 historical yet still functional culvert, no unusual or suspect items have been found during comprehensive reconnaissance of the property. A long history of sugar cultivation most likely erased any potentially important historical, cultural, or archaeological signatures; a full archaeological survey has not occurred.

[1] Giambelluca TW, Chen Q, Frazier AG, Price JP, Chen Y-L, Chu P-S, Eischeid J., and Delparte, D. 2011. The Rainfall Atlas of Hawai'i. http://rainfall.geography.hawaii.edu.

4.6 Fauna

Ground birds, including kalij pheasant (*Lophura leucomelanos*) and wild turkeys (*Meleagris gallopavo*), are frequently observed on the property though their direct impacts on the forest are small; they do carry invasive weed seeds around. Also potentially present are Pueo (*Asio flammeus*) and Io (*Buteo solitarius*). The Hawaiian hoary bat (*Lasiurus cinereus*) is almost certainly not present. The bat may live in the nearby forest, however, and therefore may be encountered in the vicinity. No 'alalā (Hawaiian crow) sightings have occurred, though the area may have been part of its original habitat. Other native birds common to the area can be found in the ecological site description prepared by the USDA NRCS and appended to this document as **Appendix A** (pp A1 – A33).

Feral pigs (*Sus scrofa*) and escaped domestic cattle (*Bos taurus*) are the largest wildlife threats to establishing forest plantings; a proposed hog-wire fence and gate system (§4.9) should eliminate both cattle and pig disturbance. Cattle are devastating to young trees of all species, as they preferentially browse meristem tissues and occasionally strip bark off saplings. The other major damage caused by cattle is erosion (**Fig. 4.6.1**), particularly in the SMZ where the animals disturb soils as they walk to the water to drink.

Figure 4.6.1. **Soil erosion in the SMZ caused by cattle**. Fencing would eliminate this damage.

4.7 Endangered species

Although a biological assessment has not been completed and is not anticipated, endangered species have not been sighted in the area. The purpose of this plan is to establish productive forestry operations on 18.82 acres, and to restore native riparian habitat on 4.45 acres. Endangered plant species will not be used for this restoration effort because their survival rates are not optimal, and the most important objective is to establish robust native species. It is anticipated that endangered animal species may use the riparian zones as corridors, though the total area is likely too limited to serve as residential habitat. Please refer to the full ecological site description prepared by the NRCS for additional details on flora and fauna associations (**Appendix A**).

4.8 Existing recreational or aesthetic values

Exceptional views of the Pacific exist throughout the property (**Fig. 4.8.1**), and the waterfall on Waiaʻama Stream is an important feature that will be preserved (**Fig. 4.8.2**). To ensure that the ocean remains visible, forestry uses are limited to areas where line of sight vectors from the home site to the ocean are uninterrupted (**Map 1**). Consequently, forestry compartments are located mauka of the North-South access route, with the exception of compartment H05, which, although below the road, nonetheless does not interfere with views (**Map 2**). Restoration of native Hawaiian species in the SMZ will be accomplished by removing invasive species (e.g. strawberry guava) and replacing the vegetation with such native species as ʻōhiʻa, uluhe, and hapuʻu ferns. These restoration activities will both improve the aesthetic appearance of the waterfall and enhance the ecological value of the riparian buffer.

Figure 4.8.1. **This exceptional ocean view would be preserved during implementation of the FMP.**

Figure 4.8.2. **Aesthetic features on the property include a small waterfall, which would be preserved during forest establishment and SMZ restoration**.

4.9 Infrastructure

4.9.1 Access

Significant access infrastructure exists on the property. A road constructed by Hāmākua Sugar Company bisects the property, and a concrete box culvert constructed in 1925 allows easy crossing of the drainage in the Northern parcel (**Map 2, Fig. 4.9.1**). Some access improvement will need to occur, chiefly removing organic debris from the existing road bed. All access improvements will be conducted within the

confines of the existing road alignment following the State of Hawaii Best Management Practices (BMP, **Appendix B**). Maintenance to the culvert appears to be unnecessary at this juncture, although the structure should be monitored for deterioration, particularly spalling of the concrete due to corrosion of steel reinforcements.

Figure 4.9.1. **A concrete culvert (top) allows the old sugar company road (bottom) to safely cross the drainage in the Northern parcel**.

4.9.2 Fencing

The Northern boundary of the property is effectively fenced with barbed wire (**Fig. 4.9.2**), but the Eastern boundary is only partially fenced, and is unfenced at the culvert. The Waia'ama Stream acts as a partial natural fence, with the waterfall and steep banks preventing cows from escaping to or entering from the State parcel to the South. The mauka (West) boundary of both parcels is unfenced, however; and cattle and feral pig access must be restricted before planting can begin. **Hunting and trapping will also be employed to control ungulates if necessary.**

Figure 4.9.2. **Barbed wire fencing and gates protect the Northern boundary of the property**. Additional fencing will be necessary across the remainder of the project perimeter.

Fencing will be needed to protect both the restored native forest and the new hardwood plantings primarily from cattle, although the mauka hog-wire fence will also restrict feral pig incursions. Improvements should be made to existing North fence to also restrict pig access; fencing shallow portions adjacent to the Waia'ama Stream is also advised in order to completely enclose the planting area. Fence material will be 6' hog-wire with a barbed skirt to prevent undermining. Fences will need periodic inspection for integrity, and will be repaired as needed every 6 months while the seedlings are young (to year 2), and annually thereafter.

V. Management Prescriptions

5.1 Compartments and Working Circles

5.1.1 Compartmentalization

To accomplish the major objectives outlined in this plan (§3.3), several specific management prescriptions (R_x) will be implemented on each land area. From administrative and operational standpoints, the property has been divided into nine management units (**Map 3**), which are referred to herein as **compartments** (**Table 5.1.1**). Compartment boundaries were designated using existing roads cut through the property before purchase. This FMP is concerned with management of SMZ and hardwood compartments, pasture compartments, though part of the property, are excluded from this plan and from this list of R_x. A unique identifying number is provided for each compartment to facilitate tracking budgets, expenditures, inventory, and yields over time. Such a numerical system is suited for managing this extensive collection of information in a database.

5.1.2 Working circles

A **working circle** is a collection of defined management R_x assigned to each compartment. For this FMP, compartments have been assigned to one of three working circles, either hardwood planting, streamside restoration, or pasture (**Table 5.1.1**). Activities in the pasture working circle are outside the scope of this management plan. A given compartment type will receive a common R_x; for example, SMZ compartments will receive invasive species control during restoration (§5.3), as well as planting of native species (§5.6). Similarly, activities conducted in hardwood compartments will include competition control prior to and after planting (§5.3), site preparation (§5.4), planting of hardwood trees (§5.5), and several maintenance operations (§5.6). Ultimately hardwoods would also be harvested (§5.7). Collectively, these sets of common R_x define a compartment type in terms of management objectives; areas of a given type are referred to as **working circles**. The scheduling and cost estimates of management are detailed at the compartment level based on area (§VI); R_x will likely be implemented according to different schedules in different compartments. The objectives for the project include restoration of native forest cover, timber production of both native and non-native trees, and riparian protection. The proposed R_x will both expand native wildlife habitat and improve overall forest health.

Table 5.1.1. **Compartments include hardwood forestry areas, streamside management zones, and pasture**. Pasture compartments do not feature in this FMP. Certain compartments are assigned road segments (length unit: miles) for reference purposes during improvement activities.

Name	Type	UID	Acres	Road Length
H01	Hardwood	101	3.89	0.08
H02	Hardwood	102	4.15	0.09
H03	Hardwood	103	3.62	0.27
H04	Hardwood	104	5.36	0.07
H05	Hardwood	105	1.80	0
P01	Pasture	201	10.51	0.18
P02	Pasture	202	7.72	0.1
S01	SMZ	401	3.52	0.17
S02	SMZ	402	0.93	0

5.2 Access and improvements

Access to the property from the main highway is via the Kaupakuea Homestead Road. To reach this road when driving North from Hilo, one should pass the 10 mile marker and then turn mauka (left) across from Sugar Mill Road (an important landmark is the large metal gear prominently displayed at this intersection). At the 0.8 mile distance after the left turn is a fork in the road—the left option should be taken, which is a one-lane paved road. On this road, one should travel 1.9 miles, at which

point there is a two-panel farm gate to the left, which is adjacent to utility pole #67. The property access route continues through this gate to the South (toward Hilo), shortly arriving at the concrete box culvert (**Fig. 4.9.1**). This road will provide operational access during the planting and maintenance phases of the project, as well as serving as the routine access for the landowner. The road is passable by heavy equipment for site preparation as well as ATV and tractor traffic for intermediate maintenance. Ultimately, harvesting equipment would also access the site through this point. Portions of the access road are in ideal condition, with a gravel base and a capped and crowned construction. Numerous sections have been covered by organic debris, however. Access improvement activities will primarily involve removing organic matter from the existing road, and the final condition of the access will conform to road construction BMP (**Appendix B**).

5.3 Riparian restoration site preparation

5.3.1 Restoration weed control

Streamside management zones require special selection of methods for controlling invasive weeds that address three concerns:

i. Herbicide agents safe for riparian areas.

ii. Effective termination of weed species.

iii. Woody debris management in advance of native species planting.

5.3.1.1 Riparian compatible herbicides

Certain herbicide agents must be avoided due to their toxicity to aquatic organisms either in fresh or salt water. Substantial restoration work next to the Waia'ama Stream will require the use of herbicides to eliminate strawberry guava and other plants, but the particular chemical and dose selected must be safe for use near streams. For example, the chemical triclopyr is not labeled for use where it may contaminate water systems, while the chemical aminopyralid is so labeled[2].

5.3.1.2 Weed control methodology

On extreme slopes (greater than 50%), two methods will be employed to deliver herbicides (**Fig. 5.3.1**). A **frill treatment** will be used for larger trees (blade or drill), with delivery of herbicide using a calibrated injection system.

Figure 5.3.1. **Frill methods for controlling larger woody stems include the traditional blade incisions (top) as well as drilled holes (bottom)**. Hand pulling or dilute foliar application of herbicides are options for juvenile woody species or mature herbaceous weeds.

[2] http://www.cdms.net/LabelsMsds/LMDefault.aspx?pd=7765&t=

In areas with relatively shallow slopes less than 50%, which is approximately the upper limit where crews can realistically work without highly specialized equipment, invasive tree cover will be controlled using a **cut stump treatment**. In this approach, trees are severed at the base using either a blade or a chainsaw; herbicides are then immediately applied to the exposed vascular tissue. To prepare for planting native tree species, further management of woody debris will be required.

5.3.1.3 Woody debris management

The current density of *P. cattleianum* cover in many sections of the riparian zone is extreme (see **Fig. 4.1.2** for examples). Following cut stump treatment, debris would be assembled into linear piles (windrows) along contour, providing at once some measure of erosion control and defining the restoration planting beds. For subsequent native tree species plantings, in the area between windrows soil would be prepared manually using a pick or motorized auger device. It will be important to carefully schedule weed termination, soil preparation, and planting. Restoration planting should begin almost immediately in cut stump treatment areas so that the plantings have maximum advantage against weeds, which would require several months to colonize. In extremely steep areas, killing the current cover and leaving it in place is acceptable—roots of the dead trees will stabilize the steep banks of the Waia‘ama Stream, and will prevent immediate re-colonization. These areas can be occupied over the long term with uluhe fern.

5.4 Hardwood Site Preparation

A clearly defined series of steps will be followed to bring the property from its current marginal pasture cover to a state ready for tree planting (**Fig. 5.4.1**). These steps are (1) terminating the current grass cover, (2) loosening the compacted pasture soils with a heavy forestry disk, and (3) constructing mounded planting rows using a bedding plow.

Figure 5.4.1. **Completed site preparation procedures result in weed-free mounded planting beds consisting of loosened soil that are designed to improve drainage around seedling roots**.

5.4.1 Pre-plant grass control

The deliberate reservation of a SMZ between hardwood compartment boundaries and the riparian areas is designed so that chemical control of pasture grasses site preparation can be utilized without posing a threat to aquatic ecosystems. Chemical control to remove weed species will be conducted approximately 2 months prior to planting, which minimizes potential for herbicide damage to planted trees. Herbicide mixes will depend on the species involved, labeled use rates, and desired mode of action. Wet soils in the area mean that particular attention is needed to prevent runoff of soil-borne chemicals or leaching of any applied materials.

5.4.2 Soil preparation

Mechanical disking and bedding should be used; a bulldozer already on-site for access improvement and home site work may be used to pull the site preparation implements in a bid to minimize costs. The R_x calls for two passes with a heavy forestry disk to incorporate the existing grass sward into the surface soil horizon, followed by one pass of a bedding plow equipped with a ripper shank to disrupt any hardpan. In

abandoned sugar plantation areas, this procedure was successfully employed for some of the Hāmākua eucalyptus plantations. In wet areas like Pepeekeo, bedding elevates the seedling root zone and allows trees to establish in soil with improved drainage. The most fertile surface soils, typically the top five inches, are collected by the bedding plow and concentrated in the center of the bed, improving soil fertility in the area immediately surrounding the seedlings. In addition, the bed height assists with competition control, physically elevating the seedlings above their herbaceous competitors and reducing the cost of subsequent chemical competition control.

5.5 Planting

5.5.1 Species Selection

The suite of hardwood species suitable for the property were selected based on their nutrient requirements, tolerance of comparable soil properties, potential market value, and (when the information was available) their growth performance in nearby plantings and trials. Species were ranked according to a composite assessment. The top-ranked species (4, **Table 5.5.1**) received this rank because they are known to grow well in this area as well as to demand a high market price. For example, *Elaeocarpus angustifolius* is among the hardest and therefore most durable tropical hardwood species, while *Eucalyptus deglupta* has some demand by Hawai'i Island cabinet makers. The species *Cupressus lusitanica* is relatively obscure in the local market, yet in its native Mexico and Central America it is in high demand for furniture and cabinetry, with wood very similar to tsugi pine (*Cryptomeria japonica*). Here, it would be used as a proven windbreak species, which with appropriate silviculture could be harvested on a limited basis. Although *Cedrella odorata* enjoys a relatively small market share in Hawaii, the available product is quickly sold and always in demand. The native Hawaiian species 'ōhi'a (*Metrosideros polymorpha*) is included in the highest rank category for restoration because it is adapted to the site and represents the best option for SMZ restoration. To emulate natural forest structure and composition, the native species plantings in the SMZ would feature shrubs as well, including mamaki (*Pipturus albidus*), naio (*Myoporum sandwicense*), and pilo (*Coprosma spp*). Understory plantings would include uluhe and hapu'u ferns. Species designated for operational use would be planted in the first year across the majority of compartments H01 and H02 (**Map 2, Table 5.5.2**). One acre in H01 would be reserved for experimental plantings (**Table 5.5.2**) such as koa, mahogany, and rosewood.

Two species are known to perform well in the area (**Fig. 5.5.1**) as well as to have an established market—these operational species would be planted across all but one acre in the compartments H01 and H02 in the first year (**Table 5.5.2**). Experimental species would be planted on the reserved acre, and their performance in the first year would determine which species are planted in compartments H03-H05 in the second year (**Table 5.5.2**). Depending on results of the experimental plantings, it may be the case that the original operational species are planted again in the remaining compartments. For the SMZ, all plantings would focus on *M*. *polymorpha*, with planting scheduled for years three through 10 (**Table 5.5.2**).

Several high value hardwoods (those ranked 3) are potentially suited to the site, and may be marketable (**Tables 5.5.1, 5.5.2**). Honduran mahogany (*Swietenia macrophylla*) and teak (*Tectona grandis*), though listed in the initial FSP proposal, grow very slowly and with poor form on an adjacent property (**Fig. 5.5.1**). As a result, these species are not favored for the project (**Table 5.5.1**). The species *Tabebuia rosea* does not have an established market, but its high wood quality suggests that it should be planted on an experimental basis (**Table 5.5.1**).

Table 5.5.1. **A selection of high value hardwood species will be planted, including experimental species in the first year**. Species are ranked according to known performance in the area. Species that have a positive track record are ranked 4; species with potential are ranked 3. Some species have high value but may suffer from disease or poor performance, or unknown factors (rank 2); species ranked 1 are, although selected in the FSP proposal, are not recommended due to known failure.

Genus	Species	Common	Use	Appr. Cost	Rank*	Weed Risk†	Share
Cedrella	*odorata*	tropical cedar	Experimental	$1.50	4	2	2%
Cupressus	*lusitanica*	Mexican cypress	Windbreak	$1.50	4	6	2%
Elaeocarpus	*angustifolius*	blue marble	Operational	$3.00	4	4	40%
Eucalyptus	*deglupta*	rainbow eucalyptus	Operational	$2.20	4	2	40%
Metrosideros	*polymorpha*	ohi'a	Restoration	$7.00	4	NA	---
Dalbergia	*latifolia*	East Indian rosewood	Experimental	$3.29	3	5	2%
Eucalyptus	*microcorys*	tallowwood	Experimental	$1.00	3	1	2%
Pterocarpus	*indicus*	narra	Experimental	$2.89	3	4	2%
Samanea	*saman*	monkeypod	Experimental	$2.75	3	4	2%
Senna	*siamea*	pheasantwood	Experimental	$2.75	3	5	2%
Acacia	*koa*	koa	Experimental	$2.00	2	NA	---
Sweitenia	*macrophylla*	Honduran mahogany	Experimental	$5.50	2	-2	2%
Tabebuia	*rosea*	trumpet tree	Experimental	$2.50	2	3	2%
Tectona	*grandis*	teak	Experimental	$4.75	1	-5	2%

* Ranking: 4: Known to succeed | 3: Expected to succeed | 2: Possible or Unknown | 1: Drawbacks

†http://www.botany.hawaii.edu/faculty/daehler/wra/full_table.asp.html

Many of the high value hardwood species proposed for this project rank between 1 and 6 on the University of Hawai'i weed risk assessment scale. Although these risk values suggest some potential for invasiveness, three factors neutralize this threat. First, the project area is completely surrounded by non-native ecosystems that contain species with far higher weed risk values—these areas act as a containment buffer. Second, the weed risk values 1 – 6 are minimal compared with the species that this project replaces (e.g. strawberry guava (WRA 18) or tropical ash (WRA 11)). Third, the land management prescription calls for aggressive brush control in the hardwood plantings; although this prescription targets primarily species that are truly weeds, it would also address any regeneration of the timber species.

Table 5.5.2. **Two operational species would be planted in compartments H01 and H02 in the first year**. Experimental species would also be planted in the first year, and their performance would determine the species set for the second planting. All species listed are abbreviated by the concatenation of the first three letters of their genus and species names.

Compartment	Type	Planting year	Species	
			Operational	Experimental
H01	Hardwood	1	Elaang, Eucdeg	Cedodo, Dallat, Eucmic, Pteind, Samsam,Sensia, Acakoa
H02	Hardwood	1	Elaang, Eucdeg	---
H03	Hardwood	2	*Pending experimental results*	
H04	Hardwood	2	*Pending experimental results*	
H05	Hardwood	2	*Pending experimental results*	
S01	SMZ	3-10	Metpol	---
S02	SMZ	3-10	Metpol	---

Figure 5.5.1. **Performance of operational species (top) is exceptional in the area**. Disfavored species originally listed in the FSP proposal should be excluded from plantings because of known performance failures (bottom left) or planted on an experimental basis (bottom right).

5.5.2 Planting

Hand planting will use a tree spade or dibble as appropriate for the nursery stock. Effective mechanical site preparation will facilitate rapid planting rates, anticipated to exceed 1,000 trees per day. Standard planting techniques require that laborers perforate a hole at least as deep as the length of the seedling root stock. The seedling is placed into this hole (1) so that the root collar is marginally lower than the level of the soil, and (2) so that the root mass is vertical. Roots should not be bent in relation to the sides of the hole ("J-rooting"), and one of the most important roles of project management during planting is to spot-check planted seedlings to ensure that J-rooting or other technical deficiencies on the part of the crew have not occurred. After the seedling is placed in the ground, loose soil is firmly packed around the roots such that the root collar is level with the soil surface. A slight tug on the seedling (without breaking the top) is used to check the adequacy of soil tamping.

5.5.3 Restoration planting

Planting techniques for restoration areas are comparable to timber, with different spacing. Windrows should be six feet apart, and trees should be spaced five feet apart. This 6' x 5' spacing yields a density of 1,452 trees per acre (hereafter, "tpa").

5.6 Maintenance

5.6.1 Fertilizer

While the soils on the property are relatively fertile, crown fertilizer treatment will aid in early seedling development and enhance their vigor (**Table 5.6.1**). The fertilizer will also aid in getting the seedling canopy out of the weed zone more quickly, thereby reducing future competition control requirements. Based on (1) the Consultant's experience with similar projects in the Hāmākua District, (2) soil test results from a similar property, and (3) detailed NRCS reports, an appropriate fertilizer formulation to apply immediately after planting is a 10-30-10 plus minor elements. For later fertilizer application, an 11-52-00 formulation is suitable. Both treatments would be a crown application in which the fertilizer dose is spread in a ring surrounding the seedling and a radial distance of six inches.

Table 5.6.1.

Formula (N-P-K)	Treatment	Timing
10-30-10+	4 oz / tree, crown 12" in diameter	At planting
11-52-00	4 oz / tree, crown at dripline	8 months

5.6.2 Competition control

Selective herbicides will be used as needed for post-planting competition control until 2 years of age or site dominance by canopy closure of young trees. Four competition control entries are anticipated, which is the standard operating procedure for other plantations in the Hāmākua District. Grasses will be the main target for this operation, as annual herbaceous species are normally not as threatening to young seedlings. The overarching objective, however, is to maintain a clean growing site for early tree development. Hand weeding will be employed if weeds are too close to the base of trees; however, this will be used judiciously as it is a costly operation. Another option is to mulch trees, using either recycled rubber rings or 3' x 3' black tree mats around the seedlings, both of which will be tested for cost effectiveness. These options would need to be reviewed on a cost basis prior to full implementation.

5.6.3 Pruning and singling

The two operational species typically do not need pruning (removal of lower branches) or singling (selection of only one competitive leader). These species are therefore expected to show good form with minimal intervention. Most of the pruning and singling efforts directed toward the first year plantings will therefore focus on the experimental species, some of which, particularly *S. saman* and *S. siamea*, are prone to excessive branching at a young age, particularly if attacked by rose beetle (§5.6.5). The potential wood value of these latter legumes is quite high, however, and could justify the expense of form control.

5.6.4 Thinning

Although thinning will certainly be needed to bring the original planting density (e.g. 454 tpa) to the final harvest density of 150 tpa at 45 years, the actual thinning operation would likely occur in the second decade of management. As such, it is not explicitly featured in this iteration of the FMP, as it is not a simple matter to predict exactly when thinning would need to occur.

Moreover, thinning is an operation that can occur over several years, and it is likely most cost effective at this scale for the landowner to conduct the thinning themselves with management guidance rather than for a forestry crew to complete the work. Ideally, this would be based on the culmination of current annual increment, or by proxy, diameter, as determined by permanent sampling plots described in the monitoring section.

5.6.5 Integrated pest management

A vigorous stand of trees is the best defense against insect and fungal pathogens, allowing

trees to resist attacks or to recover from attacks autonomously. To a significant extent, species selection should avoid pest and disease problem, since trees adapted to the site will experience less environmental stress and therefore be less susceptible to pests and diseases. However, certain species are known to be vulnerable to certain diseases, but they are nonetheless worth planting.

For example, both *S. saman* and *S. siamea* may suffer from potentially lethal defoliation by the Chinese rose beetle (*Adoredus sinicus*) when less than two or three years old. Controlling the beetles is thus only a priority when the trees are young, and the value of the wood more than offsets pest control costs. The native ʻōhiʻa may be susceptible to the fungal pathogen *Puccinia psidii*, but ʻōhiʻa is the only real option for tree species restoration in the SMZ so this risk must be taken. All pest and disease control should be accomplished in an integrated pest management (IPM) framework.

The IPM approach, which can be applied to both weed and insect pests, focuses on (1) monitoring potential pest agents, (2) identifying threshold densities or populations at which pests cause unacceptable economic damage, and (3) identifying and applying the most effective control agent. To control insect pests in IPM, the first step is to identify potential pest species. This requires a monitoring program that can take on varying degrees of sophistication. When damaging levels of the pest are discovered, the first option for control methods is typically a pheromone-based trapping system or adhesive traps. Chemical insecticides are used if control is impossible with more benign methods.

5.6.6. Monitoring

A critical element of forest management is an active and effective monitoring program. It is possible for the landowner to implement an effective monitoring program with minimal guidance from a forest management professional, and this model would be followed for the proposed project. Monitoring would take place in three spheres to determine performance of (1) experimental plantings established in year 1, (2) operational timber plantings across compartments H01 – H05, and (3) native species restoration in the SMZ. Standard tree biometric data would be collected on an annual basis for all of the trees in the experimental block, for one or two permanent sample plots per compartment (each 1/50th acre, or 26.3' diameter), and at select locations in the SMZ. In the early years, tree height and survival would be the two data categories. Once trees reach sufficient size to have a measurable diameter at 1.4 m above the ground, diameter would also be recorded. Data analysis would follow standard statistical methods. In the experimental block, first-year growth and survival data would help to determine which species would be planted in compartments H03 – H04 in the second year. Later, height and diameter growth data would reinforce financial model predictions, ultimately to develop site-specific growth curves for each of the species planted at the site.

5.7 Harvesting

In the long term, hardwood harvesting would occur using a partial selection system in which 100 tpa would be removed at first maturity (anticipated to be 40 years), and a second harvest of 50 tpa would be removed at 45 years. The precise harvest schedule will depend strongly on the difference between maintenance cost increases and increases in value with additional tree growth. Risk mitigation is also a factor that would favor limiting rotation length. This FMP assumes harvests at 40 and 45 years, which would be conducted according to standard harvesting best management practices (**Appendix B**). The vagaries of the market may ultimately dictate a different harvest regime, but this outcome is not possible to forecast.

VI. Budget and Timing

Budgeting and management schedules for the Forest Stewardship Program are presented for the first ten years of the project. Management activities through the first rotation of hardwood timber are presented in a subsequent financial analysis. The most substantial single cost for this project is fencing, which would be required to ensure that timber plantings are not destroyed by feral pigs or errant bovines. The area that must be fenced includes the hardwood timber planting areas; the SMZ does not need to be fenced because (1) the hardwood zone fence excludes cows from the SMZ and (2) feral pigs are less likely to disturb plantings amidst windrows than plantings in bedded areas. The upper bound estimate for length of fence required for this exclosure is 5,780 feet, while the lower bound length (if the North border fence is not improved) is 5,180 feet. Other large expenditures include site preparation and planting ($1,300 acre^{-1}), seedlings (average $1,050 acre^{-1}), silvicultural maintenance ($500 acre^{-1}), and SMZ restoration site preparation ($5,600 acre^{-1}, but limited to four acres). Seedlings of high value hardwood species are expensive due to a combination of factors, including rarity, difficulty of propagation, and lengthy nursery stays. Site preparation is a considerable expense because of the small scale, while silviculture consists of a variety of actions performed over two years. Each activity is assigned a corresponding NRCS code for ease of later use.

6.1 Decadal Budget

Table 6.1.1. **Anticipated costs, distributed by activity and compartment, for the first year.** Fencing includes the entire hardwood planting project perimeter (top) or excludes the North border (bottom) which is currently fenced only with barbed wire. **Costs in this section (§6.1) are on a per-acre basis, except trail construction and access control, which are on a per-foot basis, and seedling costs (per-seedling basis, 454 tpa).**

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Year 1										
Management plan	---	$193	-12	$ 752	$ 803	$ 700	$ 1,037	$ 348	$ 681	$ 180
Trail Construction	383	$1.58†	-6	$ 667	$ 751	$ 2,252	$ 584	$ -	$ -	$ -
Access Control	472	$7.00†	-6	$ 8,092	$ 8,092	$ 2,023	$ 12,138	$ 8,092	$ -	$ 2,023
Year subtotal:	---	---	---	$ 9,512	$ 9,645	$ 4,975	$ 13,758	$ 8,440	$ 681	$ 2,203
FSP %:	---	---	---	50%	50%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ 4,756	$ 4,823	$ 2,488	$ 6,879	$ 4,220	$ 340	$ 1,101
FSP share:	---	---	---	$ 4,756	$ 4,823	$ 2,488	$ 6,879	$ 4,220	$ 340	$ 1,101
Year 1 Applicant total:	$ 24,607.29			Year 1 FSP Total:	$ 24,607.29					

† Cost per foot

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Year 1										
Management plan	---	$193	-12	$ 752	$ 803	$ 700	$ 1,037	$ 348	$ 681	$ 180
Trail Construction	383	$1.58†	-6	$ 667	$ 751	$ 2,252	$ 584	$ -	$ -	$ -
Access Control	472	$7.00†	-6	$ 7,210	$ 7,210	$ 1,803	$ 10,815	$ 7,210	$ -	$ 1,803
Year subtotal:	---	---	---	$ 8,630	$ 8,763	$ 4,755	$ 12,435	$ 7,558	$ 681	$ 1,982
FSP %:	---	---	---	50%	50%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ 4,315	$ 4,382	$ 2,377	$ 6,218	$ 3,779	$ 340	$ 991
FSP share:	---	---	---	$ 4,315	$ 4,382	$ 2,377	$ 6,218	$ 3,779	$ 340	$ 991
Year 1 Applicant total:	$ 22,402.29			Year 1 FSP Total:	$ 22,402.29					

† Cost per foot

Table 6.1.2. Anticipated costs, distributed by activity and compartment, for the second year.

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Year 2										
Tree Site Preparation	490	$150	-2	$ 584	$ 623	$ 543	$ 804	$ 270	$ -	$ -
Deep Tillage	324	$350	-1	$ 1,362	$ 1,453	$ 1,267	$ 1,876	$ 630	$ -	$ -
Tree Estab. Planting	612	$150	0	$ 584	$ 623	$ -	$ -	$ -	$ -	$ -
Tree Estab. Seedlings (expr.)	612	$4.50	0	$ 2,043	$ -	$ -	$ -	$ -	$ -	$ -
Tree Estab. Seedlings (ops.)	612	$3.50	0	$ 6,181	$ 6,594	$ -	$ -	$ -	$ -	$ -
Nutrient management	590	$160	0	$ 622	$ 664	$ -	$ -	$ -	$ -	$ -
Weed Control	315	$140	2	$ 545	$ 581	$ -	$ -	$ -	$ -	$ -
Weed Control	315	$140	6	$ 545	$ 581	$ -	$ -	$ -	$ -	$ -
Integrated Pest Management	595	$114	8	$ 442	$ 471	$ -	$ -	$ -	$ -	$ -
Nutrient management	590	$160	8	$ 622	$ 664	$ -	$ -	$ -	$ -	$ -
Weed Control	315	$140	10	$ 545	$ 581	$ -	$ -	$ -	$ -	$ -
Stream Habitat Improvement	395	$7,000	10	$ -	$ -	$ -	$ -	$ -	$ 7,000	$ -
Year subtotal:	---	---	---	$ 14,073	$ 12,834	$ 1,810	$ 2,680	$ 900	$ 7,000	$ -
FSP %:	---	---	---	50%	50%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ 7,036	$ 6,417	$ 905	$ 1,340	$ 450	$ 3,500	$ -
FSP share:	---	---	---	$ 7,036	$ 6,417	$ 905	$ 1,340	$ 450	$ 3,500	$ -
Year 2 Applicant total:	**$ 19,648.35**			**Year 2 FSP Total: $ 19,648.35**						

Table 6.1.3. Anticipated costs, distributed by activity and compartment, for the third year.

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Year 3										
Site Preparation	490	$60	12	$ -	$ -	$ 217	$ 322	$ 108	$ -	$ -
Tree Estab. Planting	612	$150	12	$ -	$ -	$ 543	$ 804	$ 270	$ -	$ -
Tree Estab. Seedlings (ops.)	612	$4.00	12	$ -	$ -	$ 6,574	$ 9,734	$ 3,269	$ -	$ -
Nutrient management	590	$160	12	$ -	$ -	$ 579	$ 858	$ 288	$ -	$ -
Weed Control	315	$140	14	$ 545	$ 581	$ 507	$ 750	$ 252	$ -	$ -
Tree Pruning	660	$59	14	$ 230	$ 245	$ -	$ -	$ -	$ -	$ -
Integrated Pest Management	595	$114	16	$ -	$ -	$ 411	$ 608	$ 204	$ -	$ -
Weed Control	315	$140	18	$ -	$ -	$ 507	$ 750	$ 252	$ -	$ -
Nutrient management	590	$160	20	$ -	$ -	$ 579	$ 858	$ 288	$ -	$ -
Stream Habitat Improvement	395	$7,000	10	$ -	$ -	$ -	$ -	$ -	$ 7,000	$ -
Weed Control	315	$140	22	$ -	$ -	$ 507	$ 750	$ 252	$ -	$ -
Year subtotal:	---	---	---	$ 774	$ 826	$ 10,424	$ 15,434	$ 5,183	$ 7,000	$ -
FSP %:	---	---	---	50%	50%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ 387	$ 413	$ 5,212	$ 7,717	$ 2,592	$ 3,500	$ -
FSP share:	---	---	---	$ 387	$ 413	$ 5,212	$ 7,717	$ 2,592	$ 3,500	$ -
Year 3 Applicant total:	**$ 19,820.57**			**Year 3 FSP Total: $ 19,820.57**						

Table 6.1.4. Anticipated costs, distributed by activity and compartment, for the 4th year.

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Year 4										
Tree Pruning	660	$59	24	$ -	$ -	$ 214	$ 316	$ 106	$ -	$ -
Tree Pruning	660	$59	24	$ 230	$ 245	$ -	$ -	$ -	$ -	$ -
Weed Control	315	$110	24	$ -	$ -	$ 398	$ 590	$ 198	$ -	$ -
Stream Habitat Improvement	395	$7,000	10	$ -	$ -	$ -	$ -	$ -	$ 7,000	$ -
Critical Area Planting	342	$375	28	$ -	$ -	$ -	$ -	$ -	$ 375	$ -
Year subtotal:	---	---	---	$ 230	$ 245	$ 612	$ 906	$ 304	$ 7,375	$ -
FSP %:	---	---	---	50%	50%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ 115	$ 122	$ 306	$ 453	$ 152	$ 3,688	$ -
FSP share:	---	---	---	$ 115	$ 122	$ 306	$ 453	$ 152	$ 3,688	$ -
Year 4 Applicant total:	**$**	**4,835.78**		**Year 4 FSP Total:**		**$**		**4,835.78**		

Table 6.1.5. Anticipated costs, distributed by activity and compartment, for the 5th year.

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Year 5										
Form correction 2	666	$59	36	$ -	$ -	$ 214	$ 316	$ 106	$ -	$ -
Stream Habitat Improvement	395	$7,000	10	$ -	$ -	$ -	$ -	$ -	$ 1,848	$ 1,953
Critical Area Planting	342	$375	40	$ -	$ -	$ -	$ -	$ -	$ 1,320	$ -
Year subtotal:	---	---	---	$ -	$ -	$ 214	$ 316	$ 106	$ 3,168	$ 1,953
FSP %:	---	---	---	50%	50%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ -	$ -	$ 107	$ 158	$ 53	$ 1,584	$ 977
FSP share:	---	---	---	$ -	$ -	$ 107	$ 158	$ 53	$ 1,584	$ 977
Year 5 Applicant total:	**$**	**2,878.62**		**Year 5 FSP Total:**		**$**		**2,878.62**		

Table 6.1.6. Anticipated costs, distributed by activity and compartment, for the 6th year.

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Year 6										
Stream Habitat Improvement	395	$7,000	10	$ -	$ -	$ -	$ -	$ -	$ 2,464	$ -
Critical Area Planting	342	$375	52	$ -	$ -	$ -	$ -	$ -	$ 1,320	$ -
Year subtotal:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 3,784	$ -
FSP %:	---	---	---	50%	50%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 1,892	$ -
FSP share:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 1,892	$ -
Year 6 Applicant total:	**$**	**1,892.00**		**Year 6 FSP Total:**		**$**		**1,892.00**		

Table 6.1.7. Anticipated costs, distributed by activity and compartment, for the 7th year.

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Year 7										
Stream Habitat Improvement	395	$7,000	10	$ -	$ -	$ -	$ -	$ -	$ 2,464	$ -
Critical Area Planting	342	$375	64	$ -	$ -	$ -	$ -	$ -	$ 1,320	$ -
Year subtotal:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 3,784	$ -
FSP %:	---	---	---	50%	50%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 1,892	$ -
FSP share:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 1,892	$ -
Year 7 Applicant total:	**$**	**1,892.00**		**Year 7 FSP Total:**		**$**		**1,892.00**		

Table 6.1.8. Anticipated costs, distributed by activity and compartment, for the 8th year.

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Year 8										
Stream Habitat Improvement	395	$7,000	10	$ -	$ -	$ -	$ -	$ -	$ 2,464	$ -
Critical Area Planting	342	$375	76	$ -	$ -	$ -	$ -	$ -	$ 660	$ -
Year subtotal:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 3,124	$ -
FSP %:	---	---	---	50%	50%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 1,562	$ -
FSP share:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 1,562	$ -
Year 8 Applicant total:	**$**	**1,562.00**		**Year 8 FSP Total:**		**$**		**1,562.00**		

Table 6.1.9. Anticipated costs, distributed by activity and compartment, for the 9th year.

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Year 9										
Stream Habitat Improvement	395	$7,000	10	$ -	$ -	$ -	$ -	$ -	$ 2,464	$ -
Critical Area Planting	342	$375	88	$ -	$ -	$ -	$ -	$ -	$ 660	$ -
Year subtotal:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 3,124	$ -
FSP %:	---	---	---	50%	50%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 1,562	$ -
FSP share:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 1,562	$ -
Year 9 Applicant total:	**$**	**1,562.00**		**Year 9 FSP Total:**		**$**		**1,562.00**		

Table 6.1.10. Anticipated costs, distributed by activity and compartment, for the 10th year.

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Year 10										
Stream Habitat Improvement	395	$7,000	10	$ -	$ -	$ -	$ -	$ -	$ 2,464	$ -
Critical Area Planting	342	$375	100	$ -	$ -	$ -	$ -	$ -	$ 528	$ -
Year subtotal:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 2,992	$ -
FSP %:	---	---	---	50%	50%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 1,496	$ -
FSP share:	---	---	---	$ -	$ -	$ -	$ -	$ -	$ 1,496	$ -
Year 10 Applicant total:	**$**	**1,496.00**		**Year 10 FSP Total:**		**$**		**1,496.00**		

Table 6.1.11a. Total anticipated costs for the first decade of the hardwood project and SMZ restoration activities, where the entire project perimeter is fenced in the first year.

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Project Budget Summary: Years 1 - 10										
Compartment subtotal	---	---	---	$ 24,588	$ 23,550	$ 18,035	$ 33,095	$ 14,934	$ 42,032	$ 4,156
Plantation estab. subtotal:	---	---	---	$ 15,077	$ 13,905	$ 13,059	$ 19,336	$ 6,494	$ -	$ -
Estab. per acre subtotal:	---	---	---	$ 3,876	$ 3,351	$ 3,608	$ 3,608	$ 3,608	$ -	$ -
FSP %:	---	---	---	50%	50%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ 12,294	$ 11,775	$ 9,017	$ 16,547	$ 7,467	$ 21,016	$ 2,078
FSP share:	---	---	---	$ 12,294	$ 11,775	$ 9,017	$ 16,547	$ 7,467	$ 21,016	$ 2,078
Applicant total:				**$ 80,195**						
FSP total:				**$ 80,195**						
Project total:				**$ 160,389**						

Table 6.1.11b. Total anticipated costs for the first decade of the hardwood project and SMZ restoration activities, where fencing in the first year occurs on the South, East, and West project boundaries but not along the North boundary.

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Project Budget Summary: Years 1 - 10										
Compartment subtotal	---	---	---	$ 23,706	$ 22,668	$ 17,814	$ 31,772	$ 14,052	$ 42,032	$ 3,935
Plantation estab. subtotal:	---	---	---	$ 15,077	$ 13,905	$ 13,059	$ 19,336	$ 6,494	$ -	$ -
Estab. per acre subtotal:	---	---	---	$ 3,876	$ 3,351	$ 3,608	$ 3,608	$ 3,608	$ -	$ -
FSP %:	---	---	---	50%	50%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ 11,853	$ 11,334	$ 8,907	$ 15,886	$ 7,026	$ 21,016	$ 1,968
FSP share:	---	---	---	$ 11,853	$ 11,334	$ 8,907	$ 15,886	$ 7,026	$ 21,016	$ 1,968
Applicant total:				**$ 77,990**						
FSP total:				**$ 77,990**						
Project total:				**$ 155,979**						

6.2 Schedule of activities

Table 6.2.1. **Activities scheduled for each compartment during the first five-year management interval, after which hardwood establishment and early rotation maintenance have been completed**. Dark green cells indicate that an activity should begin in a given month of a given year in the compartment indicated. Light green cells indicate that a given activity does not occur. Note that management compartment S02 does not involve Critical Area Planting because this area bisects timber compartments and will be overtopped by timber trees.

Activity	NRCS code	Year	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
Year 1										
Management plan	---	1	-12	■	■	■	■	■	■	■
Trail Construction	383	1	-6	■	■	■	■			
Fence	472	1	-6	■	■	■	■	■		■
Year 2										
Tree Site Preparation	490	2	-2	■	■	■	■	■		
Deep Tillage	324	2	-1	■	■	■	■	■		
Tree Estab. Planting	612	2	0	■	■					
Tree Estab. Seedlings	612	2	0	■						
Tree Estab. Seedlings	612	2	0	■	■					
Nutrient management	590	2	0	■	■					
Weed Control	315	2	2	■	■					
Weed Control	315	2	6	■	■					
Integrated Pest Management	595	2	8	■	■					
Nutrient management	590	2	8	■	■					
Weed Control	315	2	10	■	■					
Stream Habitat Improvement	395	2	10						■	
Year 3										
Site Preparation	490	3	12			■	■	■		
Tree Estab. Planting	612	3	12			■	■	■		
Tree Estab. Seedlings	612	3	12			■	■	■		
Nutrient management	590	3	12			■	■	■		
Weed Control	315	3	14	■	■	■	■	■		
Tree Pruning	660	3	14	■	■					
Integrated Pest Management	595	3	16			■	■	■		
Weed Control	315	3	18			■	■	■		
Nutrient management	590	3	20			■	■	■		
Stream Habitat Improvement	395	3	10						■	
Weed Control	315	3	22			■	■	■		
Year 4										
Tree Pruning	660	4	24			■	■	■		
Tree Pruning	660	4	24	■	■					
Weed Control	315	4	24			■	■	■		
Stream Habitat Improvement	395	4	10						■	
Critical Area Planting	342	4	28						■	
Year 5										
Form correction 2	666	5	36			■	■	■		
Stream Habitat Improvement	395	5	10						■	■
Critical Area Planting	342	5	40						■	

Table 6.2.2. **Activities scheduled for each compartment during the second five-year management interval, which focuses on SMZ restoration**. Dark green cells indicate that an activity should begin in a given month of a given year in the compartment indicated. Light green cells indicate that a given activity does not occur.

Activity	NRCS code	Year	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
Year 6										
Stream Habitat Improvement	395	6	10							
Critical Area Planting	342	6	52							
Year 7										
Stream Habitat Improvement	395	7	10							
Critical Area Planting	342	7	64							
Year 8										
Stream Habitat Improvement	395	8	10							
Critical Area Planting	342	8	76							
Year 9										
Stream Habitat Improvement	395	9	10							
Critical Area Planting	342	9	88							
Year 10										
Stream Habitat Improvement	395	10	10							
Critical Area Planting	342	10	100							

6.3. Economic analysis

6.3.1 Overview

Eventual profitability of the project can be assessed using a core financial model that accepts a variety of parameters to represent the major hardwood crop tree species. For example, a financial model may accept as input the cost of site preparation and establishment, silviculture prescriptions, monitoring, and harvesting. Output from the financial model includes annual net cost, internal rate of return (IRR), and net present value (NPV). Both IRR and NPV are evaluated using a 0.4% annual increase in stumpage price above a baseline, which constrains the 45-year stumpage price to not more than 20% greater than the original. In all cases, NPV is evaluated at a real discount rate of 8%, such that when IRR drops below 8% NPV becomes negative.

For this analysis, it is assumed that the planted species is blue marble (*E. angustifolius*), and that a variety of conditions are met over the course of the rotation. In particular, a growth function dictates that the trees grow to approximately 25 m in height, achieving a diameter of 42 cm by 40 years, and 45 cm by 45 years. A growth rate of 344 bf ac^{-1} $year^{-1}$ can be derived from the growth curve, although this linear approximation properly included in the model in its original nonlinear functional form. Certain costs are globally defined, including establishment, silviculture, and maintenance—these values reflect the budgets (§6.1) and schedules (§6.2) cited above. Additional parameters are required for the economic analysis, including approximate price per board foot of harvested timber (stumpage value), as well as a cost of harvesting, which is set to a fraction of revenues in proportion to the growth curve. Harvesting is programmed to occur once, in the 45th year, and is based on a final stem density of 150 tpa.

The analysis conveys project outcomes for two cases, (I) where indirect costs of fencing are factored into the overall project profitability and (II) where fencing costs are excluded from analysis. To represent a range of possible outcomes based on price and cost fluctuations, project performance is calculated as a function of stumpage price for a fixed seedling cost, and then as a function of seedling cost for a fixed stumpage price. In this way, it is possible to assess performance along two continuous independent variables.

6.3.2 Performance with fencing costs

When fencing prices are included in the economic analysis of the project, profitability is difficult to achieve. Using a fencing cost of $36,050, or the lower price expected for this project based on not fencing the Northern boundary, profitability would occur only at relatively high cost and price parameters. In particular, for a fixed seedling cost of $3.00, NPV only becomes positive for stumpage prices approaching $2.30 (**Table 6.3.1a**). This stumpage value is potentially quite high, with $1.00 a more conservative estimate.

Table 6.3.1a. Economic analysis for increasing stumpage prices at a fixed seedling cost of $3.00 and discount rate of 8%, where fencing is considered.

	Stumpage (Seedling cost fixed at $3.00/tree)				
Costs	$1.00	$1.25	$1.50	$1.80	$2.30
IRR	5.80%	6.43%	6.92%	7.41%	8.06%
NPV	($51,394)	($41,114)	($30,835)	($18,500)	$2,059
NPV/ac	($2,731)	($2,185)	($1,638)	($983)	$109

Table 6.3.1b. Economic analysis for increasing seedling costs at a fixed stumpage price of $2.30.

	Seedling cost (Stumpage fixed at $2.30/bf)				
Costs	$1.00	$2.00	$3.00	$4.00	$5.00
IRR	8.56%	8.29%	8.06%	7.84%	7.65%
NPV	$17,881	$9,970	$2,059	($5,853)	($13,764)
NPV/ac	$950	$530	$109	($311)	($731)

Using the high stumpage price necessary to reach non-negative returns, performance may

also be assessed by varying seedling cost between $1.00 (a very low estimate) to $5.00 (a potential price depending on nursery source). When seedling prices approach $4.00, NPV dips into negative territory (**Table 6.3.1b**), suggesting that the project may be economically viable at the stumpage price of $2.30 only if seedling costs can be kept at approximately $3.00 (**Fig. 6.3.1**).

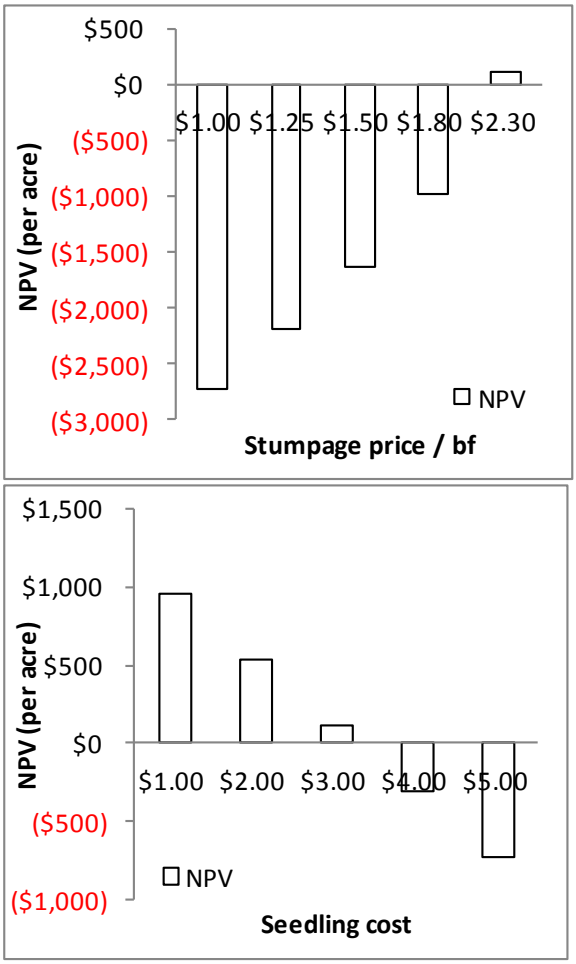


Figure 6.3.1. **Financial performance of the *E. angustifolius* investment evaluated for a 45 year rotation across a range of stumpage prices (top) and seedling costs (bottom).**

The precise cost and price points at which overall project profitability is achieved for this set of assumptions may be computed by iterating the model across the domain at which NPV transitions from negative to positive.

6.3.3 Performance without fencing costs

Planting high value hardwoods may be reasonably profitable when considering direct costs only. Fencing is an indirect cost for this project, necessary only because of factors unrelated to forestry (i.e. preventing damage from feral animals). When potential project performance is evaluated solely for the elements of the plan related directly to forestry, overall profitability is achievable within reasonable limits for costs and expected prices. Specifically, for a fixed seedling price of $3.00, IRR outweighs the discount rate when stumpage price approaches $1.50, and for a modest price increase of $0.30, per-acre NPV nears $800 (**Table 6.3.2a**).

Table 6.3.2a. Economic analysis for increasing stumpage prices at a fixed seedling cost of $3.00 and discount rate of 8%, excluding the cost of fencing.

	Stumpage (Seedling cost fixed at $3.00/tree)				
Costs	$1.00	$1.25	$1.50	$1.80	$2.30
IRR	6.98%	7.61%	8.12%	8.61%	9.27%
NPV	($18,014)	($7,735)	$2,545	$14,880	$35,438
NPV/ac	($957)	($411)	$135	$791	$1,883

Table 6.3.2b. Economic analysis for increasing seedling costs at a fixed stumpage price of $1.50.

	Seedling cost (Stumpage fixed at $1.50/bf)				
Costs	$1.00	$2.00	$3.00	$4.00	$5.00
IRR	8.99%	8.51%	8.12%	7.77%	7.47%
NPV	$18,367	$10,456	$2,545	($5,367)	($13,278)
NPV/ac	$976	$556	$135	($285)	($706)

Excluding the cost of fencing, economic performance of this project becomes quite reasonable. For example, a per-seedling cost of $3.00 is well within the price range offered by several Hawaii Island nurseries for comparable species (e.g. *E. deglupta*), and positive NPV can be achieved at this level for a stumpage price of $1.50 (**Table 6.3.2a**). In fact, seedling costs between $3.00 and $4.00 can still be borne at this stumpage price level (**Table 6.3.2b**) with positive NPV (**Fig. 6.3.2**).

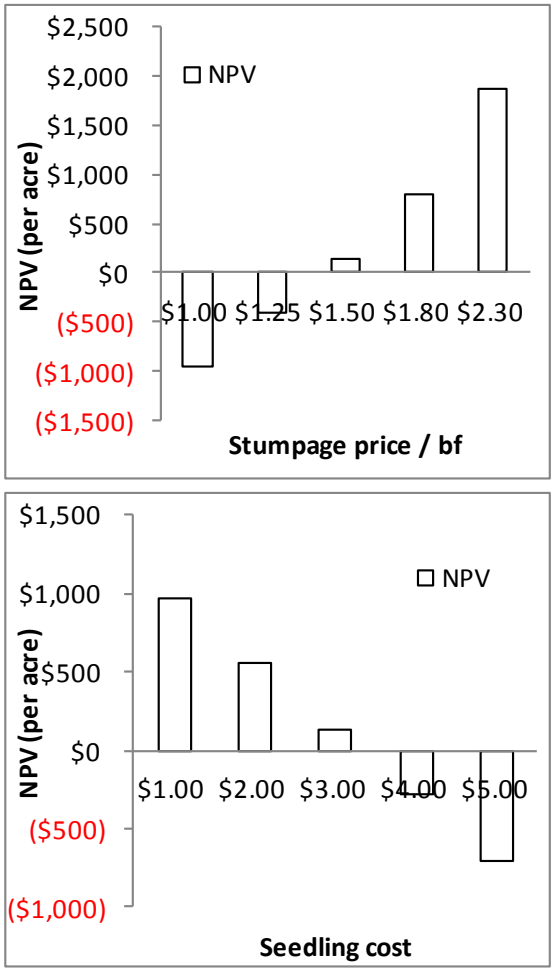
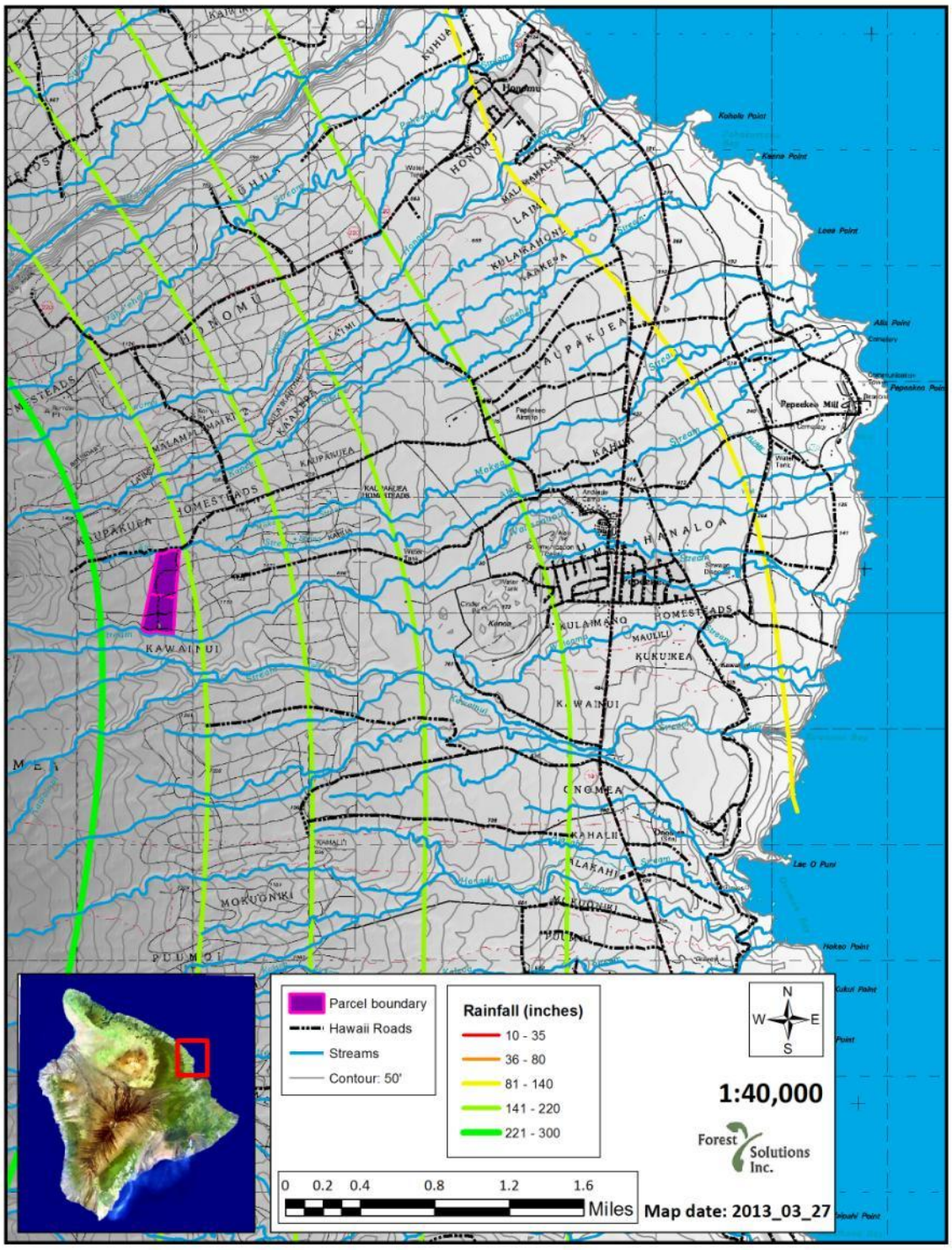


Figure 6.3.2. Financial performance of the *E. angustifolius* investment evaluated for a 45 year rotation across a range of stumpage prices (top) and seedling costs (bottom).

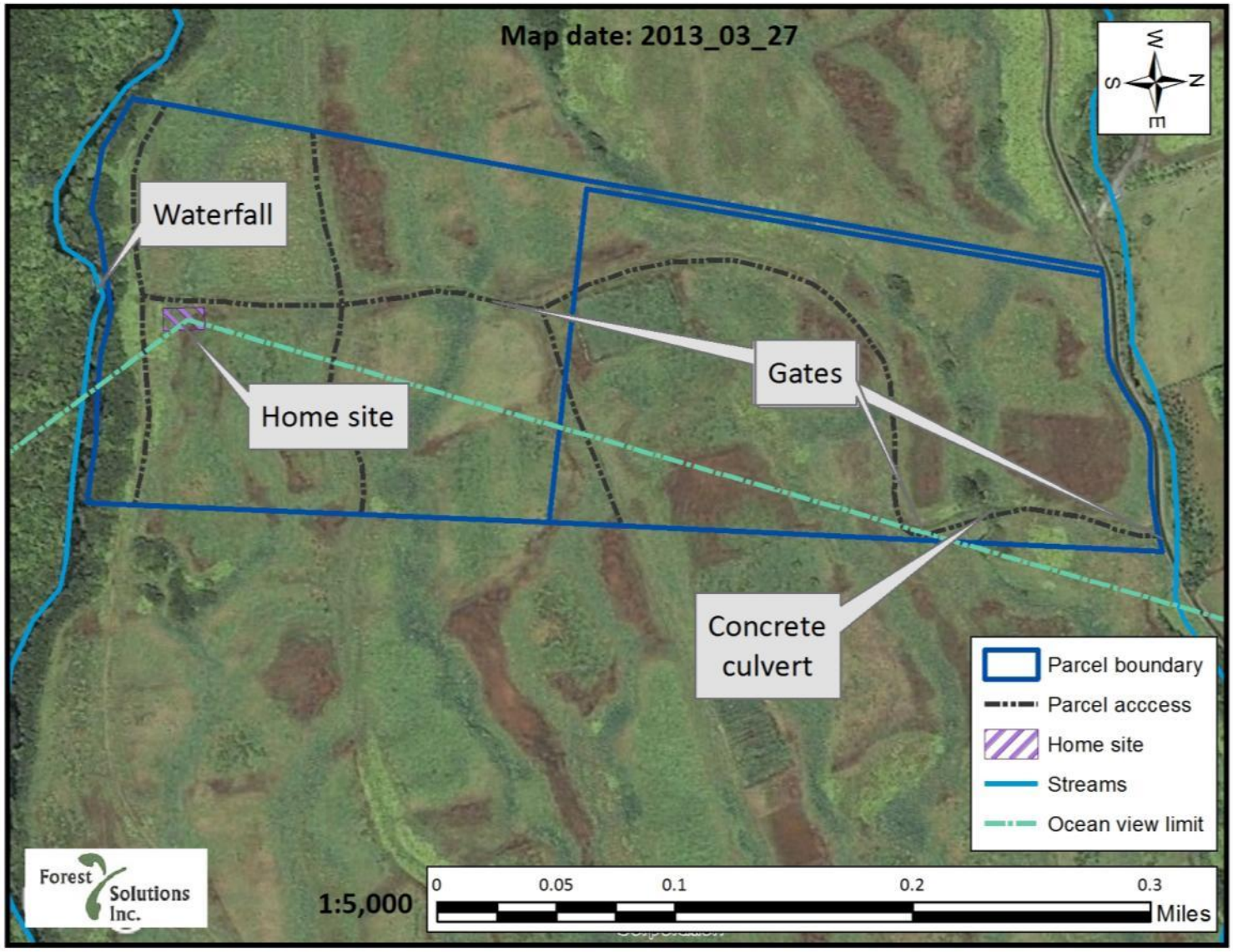
As a concluding remark about general profitability, these economic analyses impose several bounds on the initial conditions of the project in order for a return to be realized. In particular, when fencing costs are excluded, seedling costs must remain below $4.00 in order for the 45 year rotation to be profitable, assuming that stumpage is limited to $1.50 / bf. Higher stumpage prices allow the seedling costs to increase without compromising profitability. Conversely, stumpage prices less than $1.50 / bf are unprofitable when the seedling costs is $3.00; greater stumpage prices improve performance, but lower seedling costs can also achieve the same result. **The single most important factor in determining whether the project represents profit or loss is the fencing element**. At seedling costs and stumpage prices where the no-fence model is profitable, the with-fence model is well into the negative NPV range. Overall, the economic analysis provides a clear guideline for checking whether prices and costs at the outset of the project are conducive to a successful investment. Valuation of the project in the early phases (i.e. establishment) is far more accurate due to reasonably accurate knowledge about present market conditions and likely short-term trends. In contrast, the performance metrics that determine the project's future value are essentially impossible to predict either in absolute terms or in terms of uncertainty.

VII. Maps

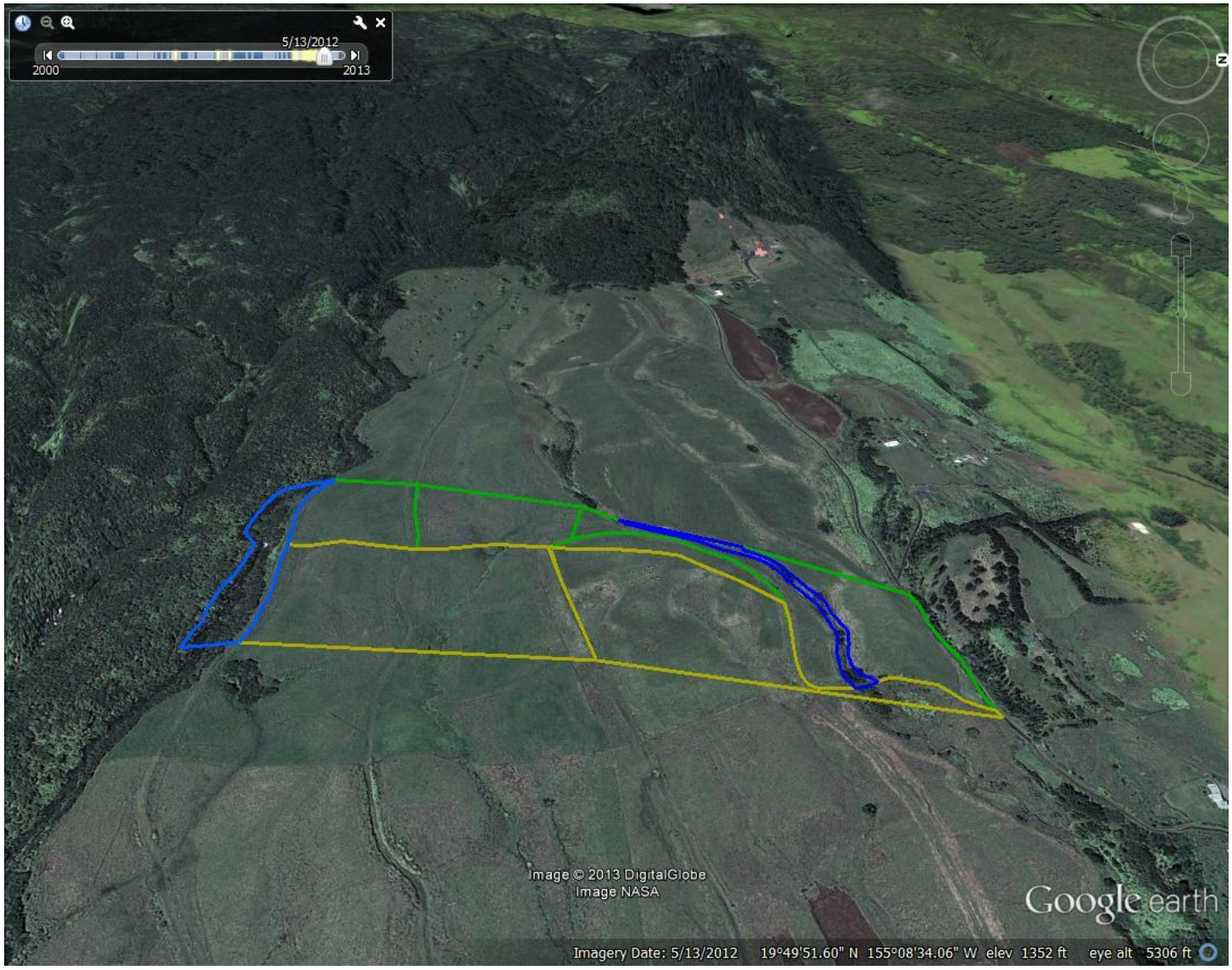


Map 1. Location of the Kaupakuea Orchards LLC property in relation to the Hāmākua Coast; Hilo is located approximately 8 miles to the South. Rainfall exceeds 141 inches annually.

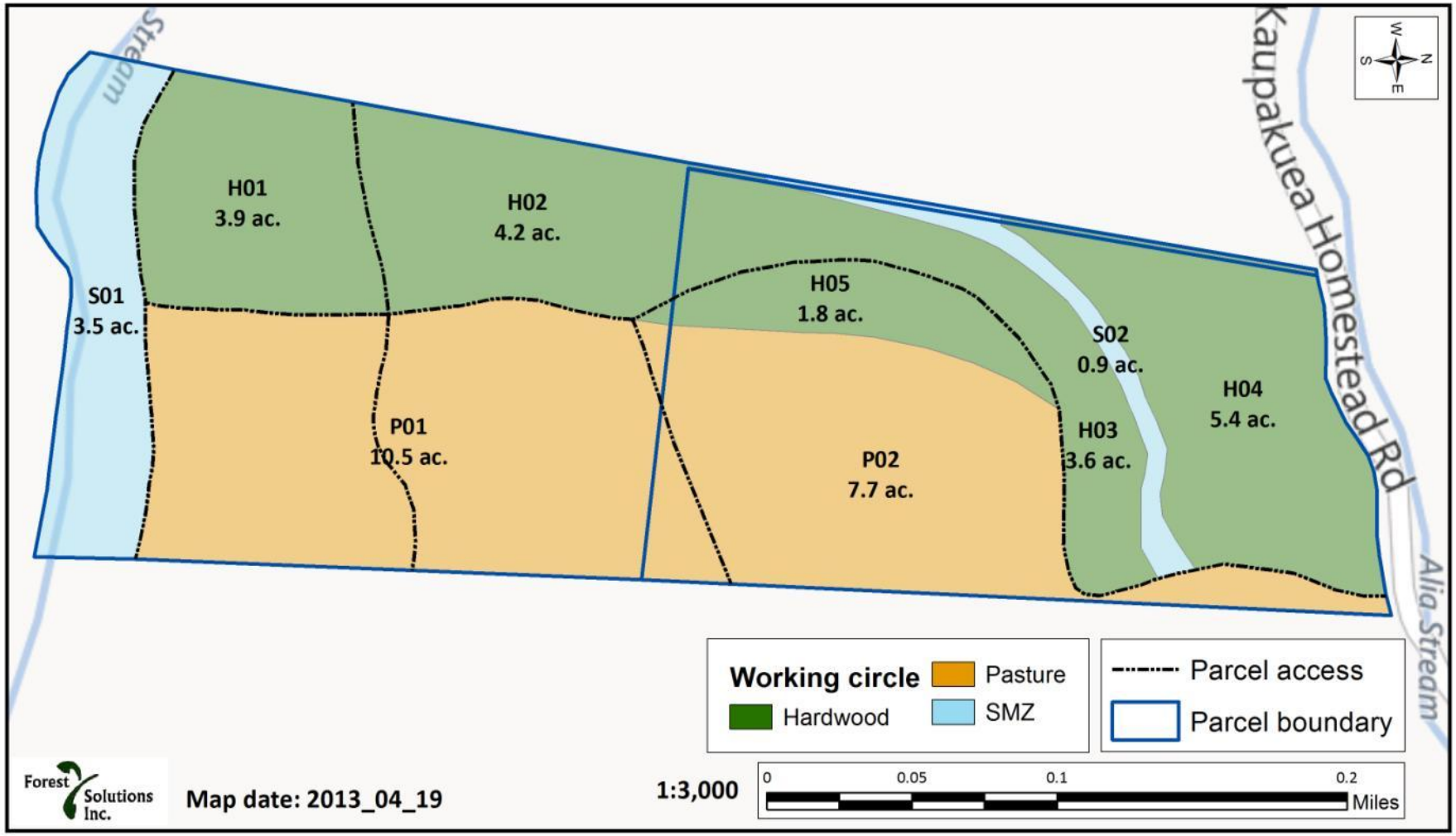
Map 2.



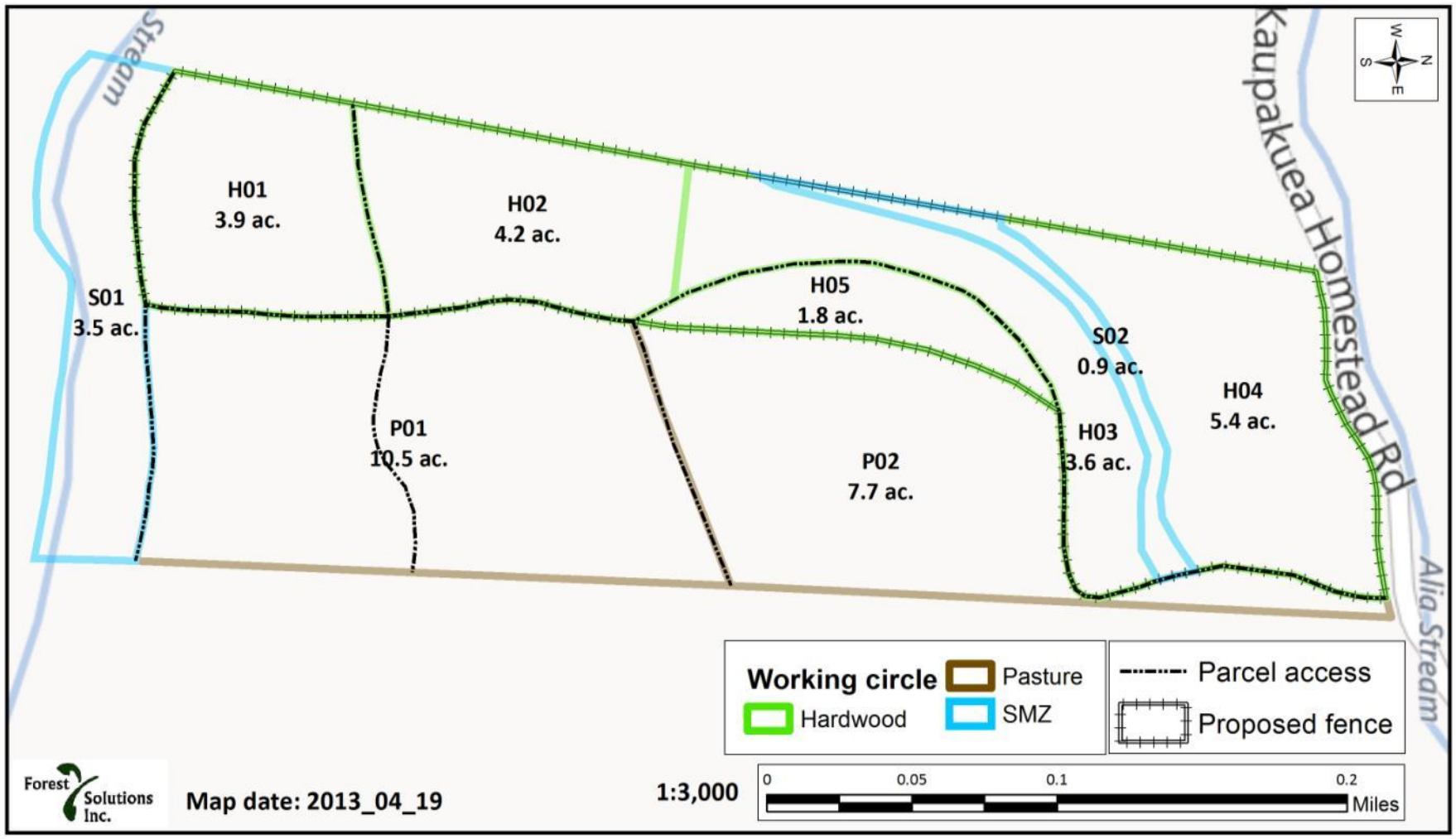
Map 2a. Parcel boundaries define a 19.59-acre parcel to the North and a second 21.90-acre flag lot to the South. The land is bordered by streams on the North and South sides. Forestry is planned for mauka sections, with open land uses planned makai of the access route. A home site is located to the South; the FMP will manage forest cover such that ocean view vectors (blue dash) are unobstructed.



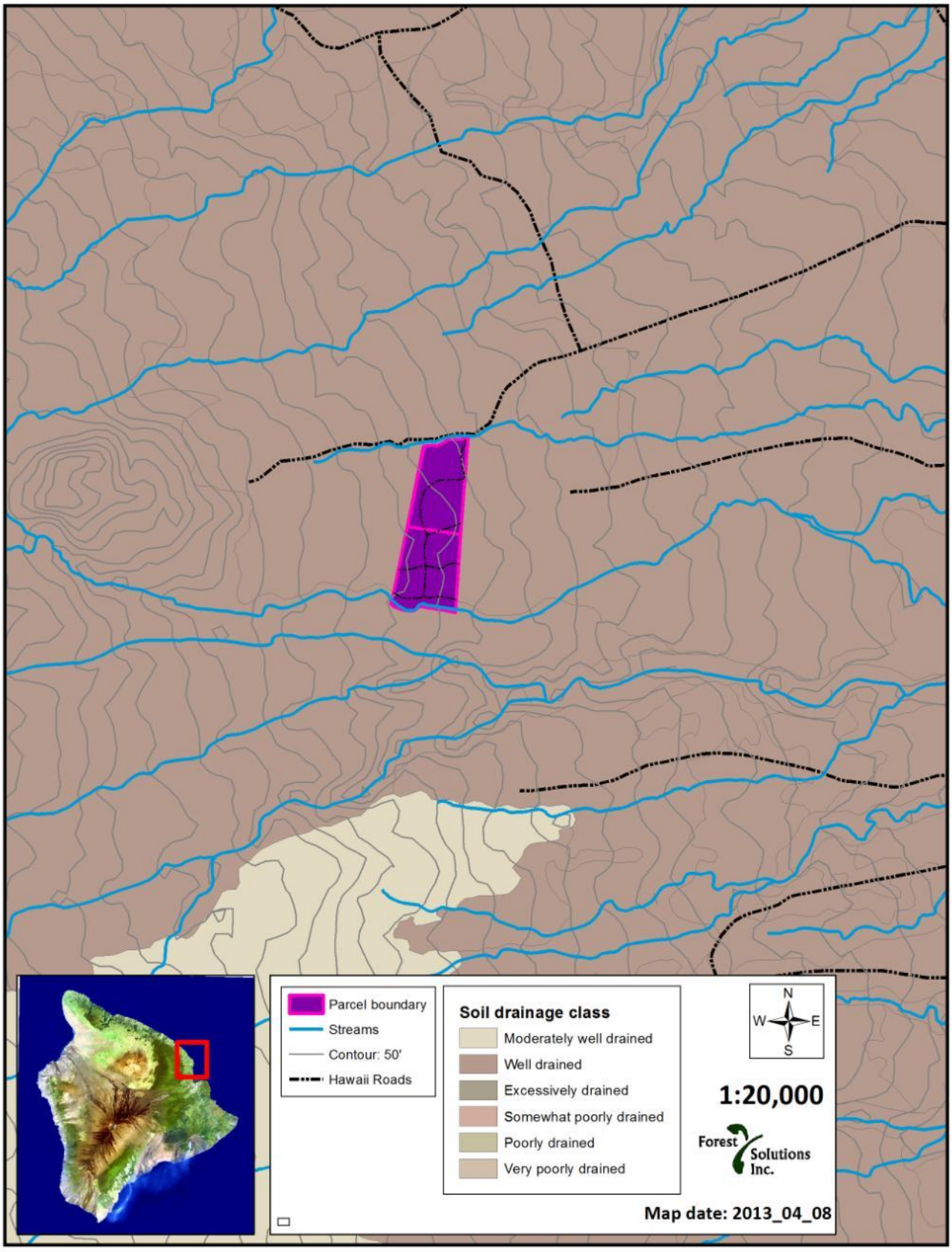
Map 2b. Compartment boundaries are defined in part by pre-existing roads, parcel boundaries, drainages, and other features that are visible in three dimensional relief. This 2012 image (Google Earth) clearly shows the Southern border SMZ and State forested parcel, with additional nearby forest up slope.



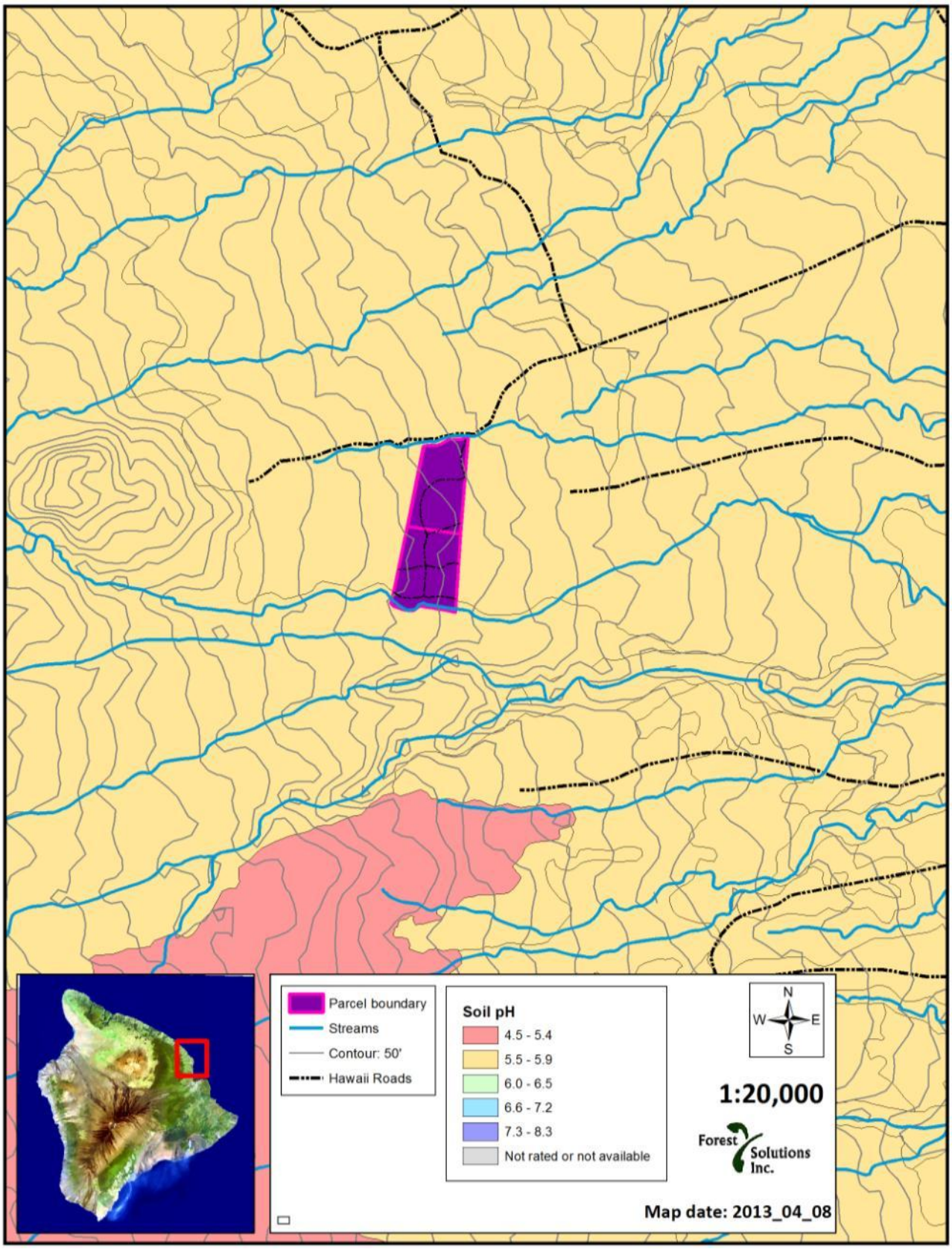
Map 3. Compartment divisions were assigned according the existence of access routes. Areas mauka of the central access route are designated for hardwood planting, while areas adjacent to the riparian sections are reserved for SMZ management.



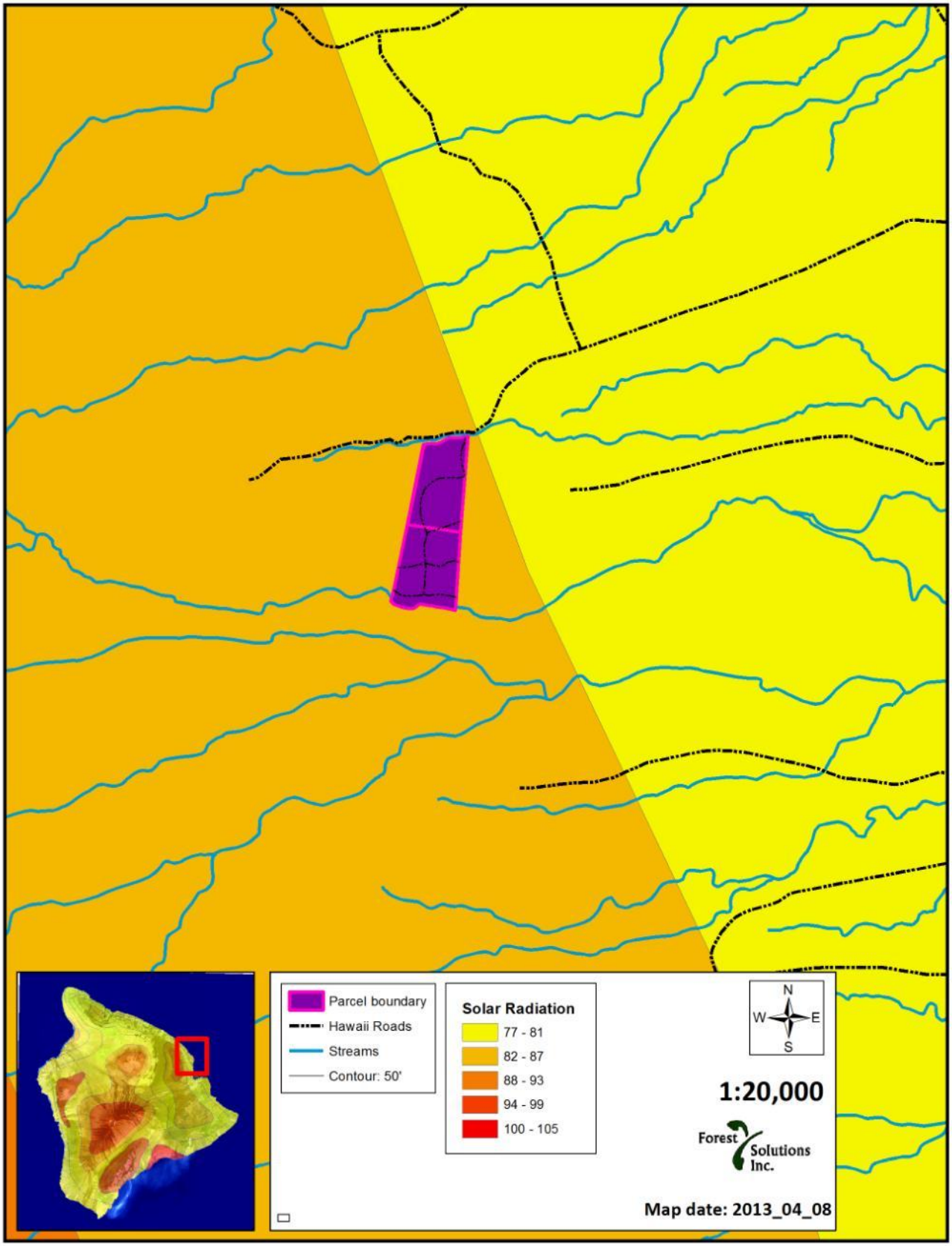
Map 4. Fencing will be necessary surrounding the hardwood planting areas, with a maximum of 5,780 feet of fencing required. Should it be decided that the existing barbed wire fence along the North boundary is adequate, total length of new fencing wo uld be 5,150 feet.



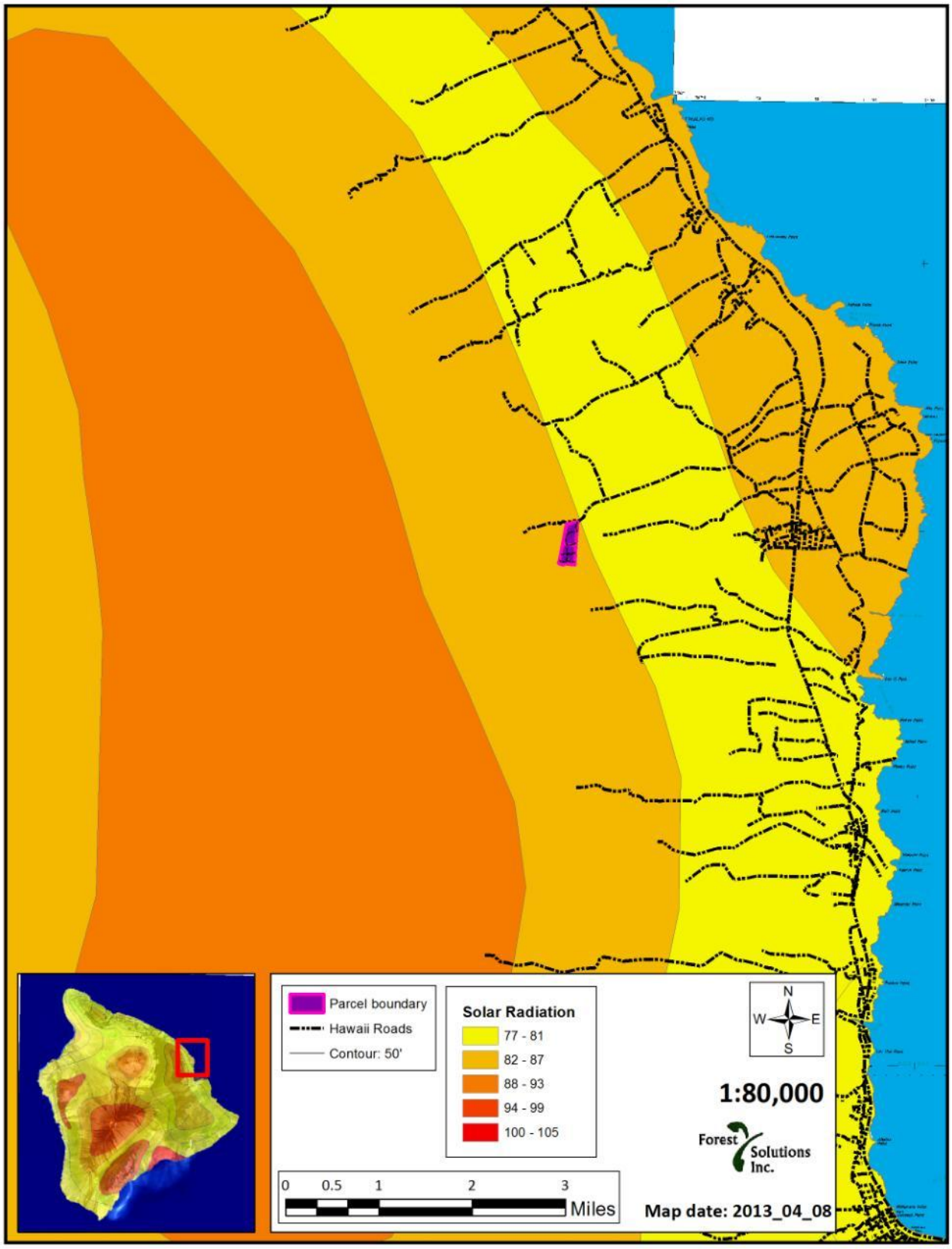
Map 5. Soils across the entire parcel are well drained.



Map 6. Uniformly acidic soils exist on the property, but the selected species are suitable for this type of substrate.



Map 7. Cloud cover in the area significantly reduces the amount of solar radiation available for photosynthesis, but several tree species thrive here nonetheless.



Map 8. Solar radiation patterns are complex over a medium scale, a consequence of the orographic effect, prevailing wind direction, the Mauna Kea cloud inversion layer, and the increase in irradiance with elevation.

VIII Appendices

Appendix A. Ecological site description (Document Page 41)

http://efotg.nrcs.usda.gov/references/public/HI/F159AY500HI_Tall_Stature_Wet_Koa-Ohia_Hapuu_Forest.doc

Appendix B. Best management practices, State of Hawaii (Document Page 66)

http://www.state.hi.us/dlnr/dofaw/pubs/BMPs_bestmanagement.pdf

Ecological Site Description

ECOLOGICAL SITE CHARACTERISTICS

Site Identification

Site Type: **Forestland**	Site ID: **F159AY500HI**	MLRA: **159A**
Colloquial Site Name: **Tall Stature Wet Koa – Ohia/Hapu`u Forest**		
Official Site Name: ***Acacia koa-Metrosideros polymorpha/Cibotium menziesii/Freycenetia arborea***		

Soils data from 1973 survey pending new soil survey.

Physiographic Features

This ecological site occurs on volcanic ash flows on sloping mountainsides of shield volcanoes. Ash flows range from deep to very deep on the underlying lava.

Landform: (1) **volcanic ash flow** Landform: (2) Landform: (3)	Minimum	Maximum
Elevation (feet):	**1200**	**6400**
Slope (percent):	**0**	**35**
Water Table Depth (inches):	--	--
Flooding: Frequency: Duration:	 **none** --	 **none** --
Ponding: Depth (inches): Frequency: Duration:	 -- -- --	 -- -- --
Runoff Class:	**low**	**medium**
Aspect: (1) **E** Aspect: (2) **N**		

Climatic Features

Average annual precipitation ranges from 50 to 140 inches. Most of the precipitation falls from November through April, with April being the wettest month. Average annual temperature ranges from 54 to 71 degrees F. The climate generally can be classified as udic and tropical in nature.

Climate chart

	Minimum	Maximum
Frost Free Period (days):	**365**	**365**
Freeze Free Period (days):	**365**	**365**
Mean Annual Precipitation (inches):	**50**	**140**

Monthly Precipitation (inches) and Temperature (^{0}F)												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. Avg.	**14.0**	**19.0**	**21.2**	**22.8**	**17.4**	**9.7**	**15.1**	**18.3**	**10.5**	**15.5**	**21.2**	**21.1**
Temp. Max.	**73.1**	**72.6**	**72.7**	**73.4**	**74.2**	**75.9**	**76.3**	**76.9**	**77.6**	**77.0**	**75.4**	**72.9**
Temp. Min.	**60.7**	**59.7**	**60.1**	**61.4**	**62.4**	**63.7**	**64.3**	**65.2**	**64.6**	**64.2**	**63.1**	**61.3**
Climate Station: (1)	**Honomu Mauka 138, 1949-1978**											

Influencing Water Features

This ecological site contains perennial streams in very deep, steep-sided gulches. The sides and bottoms of these gulches are dominated by alien trees, particularly African tulip tree (*Spathodea campanulata*), Alexandrian palm (*Archontophoenix alexandrae*), kukui (*Aleurites moluccana*), and gunpowder tree (*Trema orientale*).

Representative Soil Features

Typical soils are deep to very deep basic volcanic ash deposited over `a`a lava or pahoehoe lava. Landscape surfaces in this ecological site are 11,000 to 300,000 years old. Soils are moderately well or well drained. Available water capacity ranges from x to x inches. Available water capacity refers to the volume of water available to plants in the upper 40 inches of soil, including rocks, at field capacity. Permeability is moderately rapid to rapid. Runoff potential ranges from low to moderate. Moist surface colors range from dark reddish brown to very dark brown. Soil reactions (pH in $CaCl_2$) range from slightly to extremely acid in surface horizons and slightly to extremely acid in subsurface horizons. Soil temperature regimes are isothermic. Soil moisture regimes are udic (soil moisture control section is not dry in any part for as long as 90 cumulative days in normal years).

Predominant Parent Materials: **basic volcanic ash** Kind: deposited over `a`a lava or pahoehoe lava Origin:	Surface Texture: (1) **silt loam** Surface Texture: (2) **silty clay loam** Subsurface Texture Group: --
Surface Fragments <=3" (%Cover): 0-10 Surface Fragments >3" (%Cover): 0-10	Rock Fragments <=3" (%Volume):0-10 Rock Fragments >3" (%Volume): 0-10
Drainage Class: moderately well to well	Permeability Class: moderately rapid to rapid

	Minimum	Maximum
Depth (inches):	**50**	**>60**
Electrical Conductivity (mmhos/cm):	**0**	**2**
Sodium Adsorption Ratio:	**0**	**0**
Calcium Carbonate Equivalent (percent):	**0**	**0**
Soil Reaction (1:1 Water):		
Soil Reaction (.0-1M CaC12):		
Available Water Capacity (inches):		

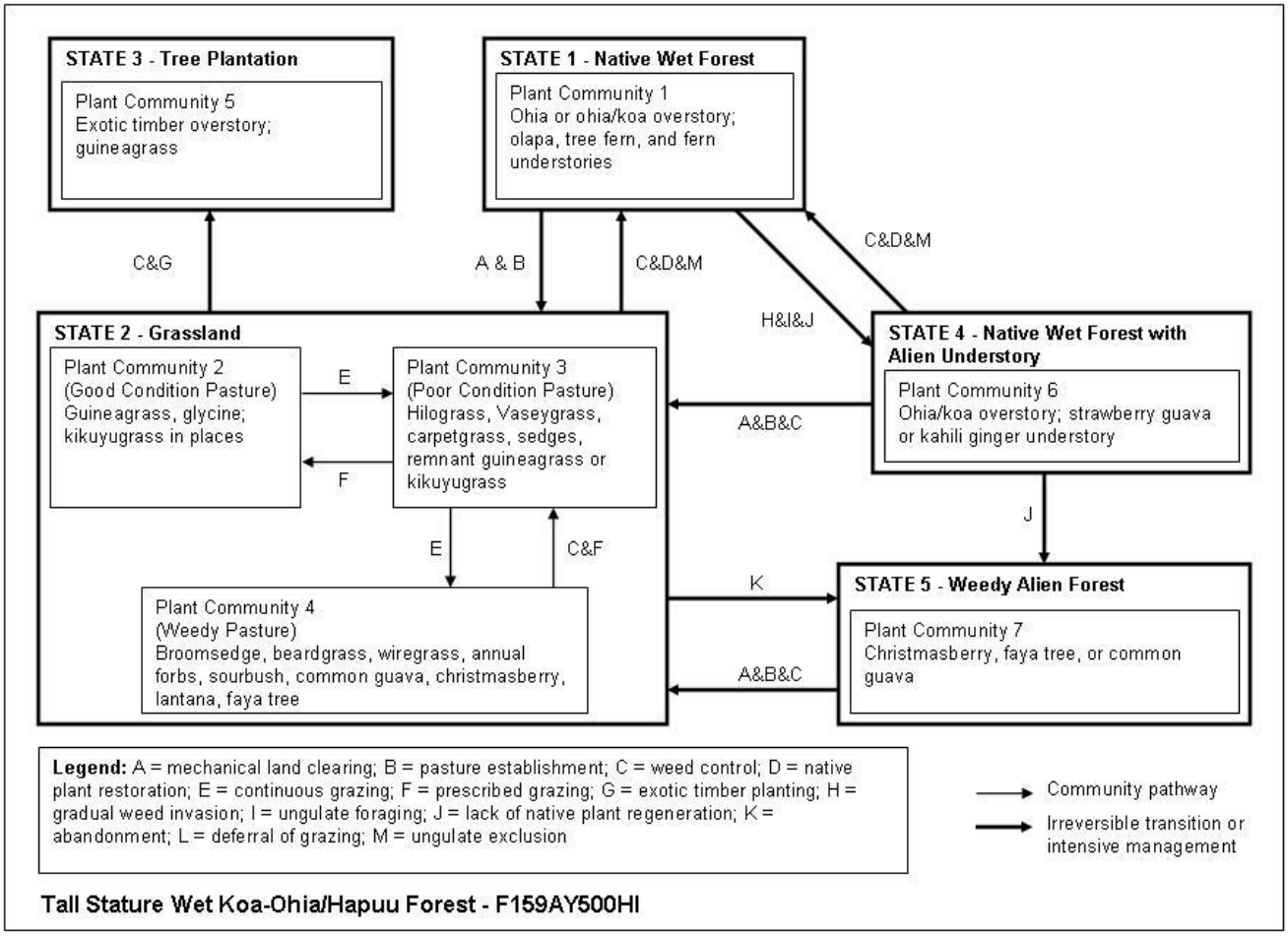
PLANT COMMUNITIES

Ecological Dynamics of the Site

This ecological site occurs on a soils formed in volcanic ash in warm, moist to wet regions of Hamakua, North Hilo, and South Hilo Districts of the Island of Hawai`i. Plant communities evolved without the presence of large mammals or the regular occurrence of fires. Much of the original forest area remains as native forest. However, the native plant community has disturbed and, in some areas, removed due to agriculture, urban development, establishment of exotic timber trees,

domestic and feral ungulate foraging, and alien species invasion. Foraging by cattle, pigs, and/or goats, or clearing and abandonment accelerate invasion by alien weeds. However, alien weeds appear able to successfully invade native stands regardless of human or ungulate disturbances. Major weeds include strawberry guava, christmasberry, kahili ginger, and alien grasses. Guineagrass and kikuyugrass pastures become infested with unpalatable grasses and shrubs under conditions of improper pasture and grazing management.

State and transition diagram



State 1 – Native Wet Forest

Plant Community 1

This state represents the Historic Climax Plant Community. The general aspect is a forest of tall overstory with an open or closed upper canopy of ohia or ohia and koa trees up to 100 feet tall, a secondary canopy of diverse trees species 30 to 60 feet tall, a dense tree fern canopy 10 to 30 feet tall, and a diverse understory of shrubs and ferns. Vines are common both on the ground and on trees. All three Big Island tree fern species are present; they frequently have very tall trunks. These forests have standing live timber of 800 to 5700 cubic feet per acre, with a representative value of about 3000 cubic feet per acre. Typical low values are about 1500 cubic feet per acre.

Overstory tree canopy cover of ohia and koa can vary from about 10% to 80%. However, understory composition is controlled by the cover of the secondary canopy of medium-stature, secondary canopy tree species and especially by the cover of tree ferns, which is usually in the range of 60% to 90%. Koa and ohia do not reproduce successfully in the typically shady understory of intact Native Wet Forest. Tree ferns, medium-stature trees such as olapa, kopiko, kolea lau

nui, kawa`u, hame, and olomea, and shrubs such as kanawao and clermontia reproduce well in the understory. The ground layer of small ferns is typically very dense when ungulates are not present.

The dominant tree canopy can be ohia trees or a combination of ohia and koa trees. We were unable to discern any consistent correlation between dominant tree canopy composition and soil type, rainfall, elevation, or any other environmental variable (PENDING NEW SOIL SURVEY OF THE HAMAKUA AREA). It is probable that long-term disturbance history controls koa occurrence. Koa is a fast growing, opportunistic species that is able to take advantage of temporary openings in the dense forest canopy.

Pathways from this state/plant community

To State 2, Grassland, via "A and B":
A = mechanical land clearing; B = pasture establishment.
Native Forest can be converted to Grassland by clearing the forest with heavy machinery; most pastures in this ecological site were originally cultivated for sugar cane and later converted to pasture. At higher, cooler elevations kikuyugrass and/or pangolagrass have been planted. At lower elevations where pastures are on old sugarcane plantations, guineagrass (a former weed in the plantations) has volunteered.

To State 4, Native Wet Forest with Alien Understory, via "H&I&J":
H = gradual weed invasion; I = ungulate foraging; J = lack of native plant regeneration.
Native Forest can convert to Native Forest with Alien Understory by gradual replacement of the understory by alien shrubs, vines, and small trees that outcompete the native understory species. This process is accelerated by ungulate foraging that disturbs the soil surface and directly destroys native plants and prevents their regeneration.

Plant species listed in the following tables have been observed in the course of field work or are derived from reliable records.
Abbreviations:
Origin: n = native (endemic or indigenous); a = alien (introduced by humans).
Type: t = tree; tf = tree fern; s = shrub; h = herb (forb); v = vine; f = fern; g = grasslike (grasses, sedges, rushes).

Composite representation of State 1, Plant Community 1, Native Wet Forest.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Metrosideros polymorpha	tr	tr	tr	tr	20	1	20	'ohi'a lehua	'ohi'a lehua	n	t	MEPO5
Acacia koa	tr	tr	tr	tr	20	1	20	koa	koa	n	t	ACKO
Cheirodendron trigynum	1	1	1	5	1		10	olapa	olapalapa	n	t	CHTR2
Perrottetia sandwicensis	tr	tr	1	1			1	olomea	olomea	n	t	PESA3
Ilex anomala	tr	tr	1	1	tr		1	kawa`u	Hawai`i holly	n	t	ILAN
Myrsine lessertiana	tr	tr	1	5			5	kolea lau nui	kolea lau nui	n	t	MYLE2
Psychotria sp.	tr	1	1	1			1	kopiko	wild coffee	n	t	PSYCH
Charpentiera sp.	tr	1	1				1	papala	papala	n	t	CHARP
Coprosma rhynchocarpa	tr	1	1	5			5	pilo	woodland mirrorplant	n	t	CORH
Antidesma platyphyllum	tr	1	1	tr			1	hame,ha`a	ha`a	n	t	ANPL2
Antidesma pulvinatum	tr	1	1	tr			1	hame	hame	n	t	ANPU2
Gardenia remyi	?	?	?	?			?	nanu	Remy's gardenia	n	t	GARE
Hedyotis terminalis	tr	tr	1				1	manono	variable starviolet	n	t	HETE21
Pritchardia lanigera	?	?	?	?			?	loulu	lou`ulu	n	t	PRLA4
Urera glabra	tr	tr	1	1			1	opuhe	hopue	n	t	URGL
Myrsine sandwicensis	tr	tr	tr				tr	kolea lau li`i	kolea lau li`i	n	t	MYSA2
Platydesma remyi	?	?	?				?	pilo kea	Hawai`i pilo kea	n	t	PLRE4
Cibotium glaucum	1	1	20	40			50	hapu`u	hapu`u	n	tf	CIGL
Cibotium menziesii	1	1	5	10			20	hapu`u `i`i	hapu`u li	n	tf	CIME8
Cibotium chamissoi	tr	tr	tr	1			1	hapu`u	Chamisso's manfern	n	tf	CICH
Clermontia lindseyana	?	?	?				?	`oha wai	hillside clermontia	n	s	CLLI3

Composite representation of State 1, Plant Community 1, Native Wet Forest.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Clermontia peleana	?	?	?				?		pele clermontia	n	s	CLPE2
Clermontia sp.	1	1	1				1	`oha wai	clermontia	n	s	CLERM
Cyrtandra tintinnabula	?	?					?	ha`iwale	Laupahoehoe cyrtandra	n	s	CYTI
Pipturus albidus	tr	tr	1				1	mamaki	Waimea pipturus	n	s	PIAL2
Broussaisia arguta	tr	1	5				5	kanawao	kanawao	n	s	BRAR6
Eurya sandwicensis	?	?					?	anini	anini	n	s	EUSA6
Vaccinium calycinum	1	1	1				1	ohelo	ohelo kau la`u	n	s	VACA8
Styphelia tameiameiae	tr	tr					tr	pukiawe	pukiawe	n	s	STTA
Trematolobelia grandifolia	?	?	?				?		largeflower false lobelia	n	s	TRGR8
Cyanea platyphylla	?	?	?				?	haha	Puna cyanea	n	s	CYPA7
Cyanea tritomantha	?	?	?				?	`aku	`aku`aku	n	t	CYTR6
Cyrtandra giffardii	?	?					?		forest cyrtandra	n	s	CYGI3
Cyrtandra platyphylla	1	1					1	`ilihia	`ilihia	n	s	CYPL5
Cyrtandra sp.	tr	1					1	ha `iwale	Cyrtandra	n	s	CYRTA
Peperomia sp.	1						1	`ala`ala wai nui	peperomia	n	h	PEPER
Astelia menziesiana	1						1	kaluaha	pua'akuhinia	n	h	ASME4
Phytolacca sandwicensis	tr	tr					tr	popolo ku mai	Hawai`i pokeweed	n	h	PHSA2
Joinvillea ascendens	?	?					?	`ohe	`ohe	n	h	JOAS
Korthalsella sp.	1						1	hulumoa	korthal mistletoe	n	h	KORTH
Stenogyne calaminthoides	1						1		bog stenogyne	n	v	STCA9
Stenogyne macrantha	?						?		Hawai`i stenogyne	n	v	STMA3
Stenogyne scrophularioides	?						?		mohihi	n	v	STSC4
Phyllostegia floribunda	?						?		Hawai`i phyllostegia	n	v	PHFL6
Phyllostegia racemosa	?						?		kiponapona	n	v	PHRA6
Phyllostegia vestita	?						?		streambed phyllostegia	n	h	PHVE4
Phyllostegia warshaueri	?						?		Laupahoehoe phyllostegia	n	v	PHWA3
Rubus hawaiiensis	1	1					1	`akala	Hawai`i blackberry	n	v	RUHA
Smilax melastomifolia	1						1	hoi kuahiwi	Hawai`i greenbrier	n	v	SMME
Freycenetia arborea	1						1	`ie`ie	`ie`ie	n	v	FRAR
Alyxia oliviformis	1	1					1	maile	maile	n	v	ALOL2
Embelia pacifica	1						1	kilioe	kilioe	n	v	EMPA
Athyrium microphyllum	1						1	`akolea	akolea	n	f	ATMI
Sadleria sp.	1	1	1				1	`ama`u	Sadleria	n	f	SADLE
Adenophorus pinnatifidus	1						1		graceful kihifern	n	f	ADPI
Adenophorus tamariscinus	1						1	wahini noho mauna	wahini noho mauna	n	f	ADTA
Asplenium schizophyllum	1						1		fringed spleenwort	n	f	ASSC8
Coniogramme pilosa	1						1	lo`ulu	loulu	n	f	COPI3
Dicranopteris linearis	1						1	uluhe	Old World forkedfern	n	f	DILI
Diplazium sandwichianum	1	1					1	ho`i`o	Hawai`i twinsorus fern	n	f	DISA3
Dryopteris hawaiiensis	1						1		Hawai`i woodfern	n	f	DRHA
Dryopteris sandwicensis	1	1					1		Pacific woodfern	n	f	DRSA
Dryopteris wallichiana	1	5					5	`i`o nui	alpine woodfern	n	f	DRWA
Grammitis tenella	1						1	kolokolo	kolokolo	n	f	GRTE
Lepisorus thunbergianus	1						1	pakahakaha	weeping fern	n	f	LETH6
Lycopodiella cernua	tr						tr	pakahakaha	weeping fern	n	f	LETH6

Composite representation of State 1, Plant Community 1, Native Wet Forest.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Mecodium recurvum	1						1	`ohi`a ku	ohiaku	n	f	HYRE
Nephrolepis exaltata	1						1	Boston swordfern	Boston swordfern	n	f	NEEX
Nothoperanema rubiginosum	1						1		island lacefern	n	f	NORU
Ophioderma pendulum	1						1	puapuamoa	Old World adder's tongue	n	f	OPPEP
Pneumatopteris sandwicensis	1	1					1	ho`i`o kula	Hawai`i airfern	n	f	PNSA
Psilotum complanatum	1						1	moa nahele	flatfork fern	n	f	PSCO3
Psilotum nudum	1						1	moa	whisk fern	n	f	PSNU
Pteridium aquilinum	tr						tr	brackenfern	western brackenfern	n	f	PTAQ
Pteris cretica	1						1	`oali	Cretan brake	n	f	PTCR2
Pteris excelsa	1						1	waimakanui	waimakanui	n	f	PTEX
Sticherus owhyensis	1						1	uluhe	Hawai`i umbrella fern	n	f	STOW
Diplopterigium pinnatum	tr						tr	uluhe lau nui	scrambling fern	n	f	DIPI3
Elaphoglossum crassifolium	1						1	stag's tongue, `ekaha	royal tonguefern	n	f	ELCR2
Elaphoglossum palaeaceum	1						1	maku`e	ekaha	n	f	ELHI3
Sphenomeris chinensis	tr						tr	pala`a	Chinese creepingfern	n	f	ODCH
Microlepia strigosa	1	1					1	palapalai	palapalai	n	f	MIST4
Asplenium sp.	1	1					1		spleenwort	n	f	ASPLE
Asplenium normale	1						1		rainforest spleenwort	n	f	ASNO4
Vandenboschia sp.	1						1	vandenboschia	vandenboschia	n	f	VANDE
Uncinia uncinata	1						1		Hawai`i birdcatching sedge	n	g	UNUN
Carex wahuensis	1						1		Oahu sedge	n	g	CAWA
Carex alligata	1						1		Hawai`i sedge	n	g	CAAL12
Grasslike	1						1					
Native Forbs	1						1					
Exotic Forbs												
Native Vines/Epiphytes	5	1					5					
Exotic Vines												
Small ferns	20	10	1				30					
Native Shrubs	1	5	10				10					
Exotic Shrubs												
Native Trees	1	1	10	20	40	1	60					
Tree ferns (native)	1	1	20	50			70					
Exotic Trees & tree ferns												
Lichen												
Moss (on ground & logs)	10						10					
Moss (on trees)	20						20					
Logs on ground (>4" dia.)	5						5					
Litter (not logs)	70						70					
Surface rocks (>3" dia.)	1						1					
Surface rocks (≤3" dia.)	1						1					
Bare Soil	tr						tr					

Understory species canopy cover under a range of overstory canopy covers in Native Wet Forest. Overstory includes upper tree, secondary tree, and tree fern canopies combined.

Common Name	Scientific Name	Understory Species Canopy Cover as a function of Overstory Canopy Cover		
		Overstory Canopy Cover Percent		
		50	***70***	***90***
'ohi'a lehua	*Metrosideros polymorpha (seedlings and saplings)*	5	1	tr
koa	*Acacia koa (seedlings and saplings)*	5	1	tr
mamaki	*Pipturus albidus*	5	1	tr
olapa	*Cheirodendron trigynum*	10	5	5

State 1, Plant Community 1, Native Wet Forest.

State 2 – Grassland

This state is comprised of three grassland plant communities. Most of the pastures in this ecological site are on former sugar plantations where guineagrass was an agricultural weed. Guineagrass now has taken over these lands as the dominant pasture grass. Kikuyugrass is the dominant grass, sometimes with pangolagrass, in some higher elevation areas where these species have been planted. More information on these kikuyugrass/pangolagrass pastures can be found in Ecological Site Description F160XY502HI – Mauna Kea Koa-Mamane.

Plant Community 2 (Good Condition Pasture) consists of guineagrass with an admixture of glycine (perennial soybean). Continuous grazing that does not allow the favored forage species time to recover from defoliation results in Plant Community 3 (Poor Condition Pasture), which is dominated by lower value forage species but contains enough remnant guineagrass (or kikuyugrass in some cases) to allow for a transition back to Plant Community 1 with prescribed grazing.

Longer-term continuous grazing leads to Plant Community 4 (Weedy Pasture), which consists of low value grass species and increasing cover of alien shrubs and tree saplings. Improvement of this Plant Community requires weed control and prescribed grazing.

Pathways from this state

To State 1 – Native Forest, via "C&D&M":

C = weed control; D = lack of fire; D = native plant restoration; M = ungulate exclusion.

It may be possible to recreate a plant community resembling Native Forest from Pasture. Weed control must be applied to pasture species and the many opportunistic plant species that invade the site. Weed control would be a perpetual process to capture and maintain the site at least until a closed canopy of native trees developed. Animal foraging (domestic or feral) would have to be eliminated by excluding all ungulates from the restoration site, but domestic ungulates would be useful to initially reduce grass cover and to manage vegetation outside the restoration site perimeter. Extensive planting of native species would follow. Increased shade from trees growing on the site causes a shift from C4 (warm-season) grass dominance (typically guineagrass or kikuyugrass) to C4 or C3 (cool-season) shade-tolerant grasses (typically meadow ricegrass, Hilograss, or carpetgrass). This shade tolerant grass layer can be very dense and detrimental to establishment of native plants. It may be possible to suppress these grasses by planting native shrubs and tree ferns that produce dense shade near the ground and litter that covers the grass.

To State 3 – Tree Plantation, via "C&G":

C = weed control; G = exotic timber planting.

Pasture may be converted to Tree Plantation by site preparation and planting of timber species (usually eucalyptus) and weed control.

To State 5 – Weedy Alien Forest, via "K":

K = abandonment.

Abandonment of pastures leads to rapid invasion of alien tree species that take over from the initial growth of grasses and weedy shrubs. Common weed tree species are strawberry guava, christmasberry, faya tree, and common guava.

Plant Community 2 – Good Condition Pasture

The dominant grass species in this pasture type is guineagrass that has volunteered in old sugarcane plantations. In higher elevation areas, kikuyugrass and sometimes pangolagrass have been planted.

Pathways from this plant community

To Plant Community 3, Poor Condition Pasture, via "E":

E = continuous grazing.

Good Condition Pasture degrades to Poor Condition Pasture by continuous grazing that weakens preferred guineagrass or kikuyugrass and legumes in relation to poor forage species such as Hilograss, narrowleaf carpetgrass, and sedges.

State 2, Plant Community 2, Good Condition Pasture.

This list of plants and their relative proportions are based on near-normal years. Fluctuations in species composition and relative production may change from year to year depending upon precipitation or other climatic factors.

Common/Group Name	Scientific Name	Symbol	Functional Group	lbs./acre	% Comp
GRASSES					
Naturalized Warm Season Tallgrasses			**1**	**11,900-14,000**	**85-100**
guineagrass	Urochloa maxima	URMA3	1	11,900-14,000	85-100
Napier elephantgrass	Pennisetum purpureum	PEPU2	1	T-140	T-1
Naturalized Warm Season Mid-Grasses			**2**	**T-140**	**T-1**
kikuyugrass	Pennisetum clandestinum	PECL2	2	T-300	T-5
Hilograss	Paspalum conjugatum	PACO14	2	T-140	T-1
Rhodesgrass	Chloris gayana	CHGA2	2	T-140	T-1
Green kyllinga	Kyllinga brevifolia	KYBR	2	T-140	T-1
Vaseygrass	Paspalum urvillei	PAUR2	2	T-140	T-1
Natal redtop	Melinis repens	MERE9	2	T-140	T-1
smutgrass	Sporobolus indicus	SPIN4	2	T-140	T-1
East Indian crabgrass	Digitaria setigera	DISE6	2	T-140	T-1
hairy crabgrass	Digitaria sanguinalis	DISA	2	T-140	T-1
wiregrass (goosegrass)	Eleusine indica	ELIN3	2	T-140	T-1
broomsedge	Andropogon virginicus	ANVI	2	T-140	T-1
beardgrass	Schizachyrium condensatum	SCCO10	2	T-140	T-1
FORBS					
Naturalized Forbs			**3**	**140-700**	**1-5**
perennial soybean	Neonotonia wightii	NEWI2	3	140-420	1-3
three-flowered ticktrefoil	Desmodium triflorum	DETR4	3	140-420	1-3
Japanese tea	Chamaecrista nictitans	CHNI2	3	T-140	T-1
sensitive plant	Mimosa pudica	MIPU8	3	T-140	T-1
smooth rattlepod	Crotalaria pallida var. obovata	CRPAO	3	T-140	T-1
lilac tasselflower	Emilia sonchifolia	EMSO	3	T-140	T-1
common sow thistle	Sonchus oleraceus	SOOL	3	T-140	T-1
lion's ear mint	Leonotis nepetifolia	LENE	3	T-140	T-1
spiny amaranth	Amaranthus spinosus	AMSP	3	T-140	T-1
SHRUBS					
Naturalized Shrubs, Half-Shrubs, and Trees			**4**	**140-700**	**1-5**
bush indigo	Indigofera suffruticosa	INSU	4	140-420	T-1
sourbush	Pluchea carolinensis	PLCA10	4	T-140	T-1
guava	Psidium guajava	PSGU	4	T-140	T-1
false mallow	Malvastrum coromandelianum	MACO6	4	T-140	T-1
christmasberry	Schinus terebinthifolius	SCTE	4	T-140	T-1
balloon plant	Asclepias physocarpa	ASPH2	4	T-140	T-1
castor bean	Ricinum communis	RICO3	4	T-140	T-1

State 2, Plant Community 2, Good Condition Pasture.

Annual Production lbs./acre	
Above Normal	16,000
Normal	14,000
Below Normal	10,000
Percent Ground Cover	
Plant	65
Litter	30
Cryptogams	0
Bare ground	5

Plant Community 3 – Poor Condition Pasture

Poor Condition Pasture is dominated by grasses of low forage value such as Hilograss, narrowleaf carpetgrass, and sedges. Desirable forage legumes have been grazed out.

Pathways from this plant community

To Plant Community 2, Good Condition Pasture, via "F":

F = prescribed grazing.

Poor Condition Pasture can be reconverted to Good Condition Pasture by prescribed grazing. A prescribed grazing plan provides for intensive but temporary grazing of pastures that ensures that cattle consume some low-value forage species along with preferred forages and allows preferred forages time to recover from defoliation. The grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing. Invading broomsedge and beardgrass may be controlled by mowing their seed stalks before seed set and by liming to increase soil pH.

To Plant Community 4, Weedy Pasture, via "E":

E = continuous grazing.

Poor Condition Pasture degrades to Weedy Pasture by long-term continuous grazing. Guineagrass cover is greatly reduced and largely replaced by low-value forage grasses. Weedy forbs such as spiny amaranth, alien blackberries, and alien shrubs such as sourbush have increased. Broomsedge and beardgrass often are the most abundant grass species.

Composite representation of State 2, Plant Community 3, Poor Condition Pasture.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Psidium guajava	1	1	1				1	common guava	guava	a	t	PSGU
Schefflera actinophylla	tr						tr	octopus tree	octopus tree	a	t	SCAC2
Falcataria moluccana	tr	tr					tr	albizia	peacocksplume	a	t	FAMO
Schinus terebinthifolius	tr	1	1				1	christmasberry	Brazilian peppertree	a	t	SCTE
Spathodea campanulata	tr	tr					tr	African tuliptree	African tuliptree	a	t	SPCA2
Morella faya	tr	tr					tr	faya tree	firetree	a	t	MOFA
Pluchea carolinensis	tr	1	1				1	sourbush	cure for all	a	s	PLCA10
Indigofera suffruticosa	1	1					1	bush indigo	anil de pasto	a	s	INSU
Ricinus communis	tr	1	1				1	castor bean	castor bean	a	s	RICO3
Rubus argutus	tr	1					1	Florida blackberry	sawtooth blackberry	a	v	RUAR2
Rubus rosifolius	tr	1					1	thimbleberry	West Indian raspberry	a	v	RURO
Nephrolepis multiflora	1						1	scaly swordfern	scaly swordfern	a	f	NEHI
Pteridium aquilinum	tr						tr	brackenfern	western brackenfern	n	f	PTAQ
Dicranopteris linearis	tr						tr	uluhe	Old World forkedfern	n	f	DILI
Ageratina riparia	tr						tr	Hamakua pamakani	spreading snakeroot	a	h	AGRI2
Asclepias physocarpa	tr	1					1	balloonplant	balloonplant	a	h	ASPH2
Chamaecrista nictitans	1						1	partridge pea	partridge pea	a	h	CHNI2
Mimosa pudica	1						1	sensitiveplant	shameplant	a	h	MIPU8
Commelina diffusa	1						1	honohono	climbing dayflower	a	h	CODI5
Crotalaria pallida var. obovata	1						1	smooth rattlepod	smooth rattlebox	a	h	CRPAO
Desmodium triflorum	tr						tr		threeflower ticktrefoil	a	h	DETR4
Emilia sonchifolia	1						1	Flora's paintbrush	lilac tasselflower	a	h	EMSO
Sonchus oleraceus	1						1	pualele	common sowthistle	a	h	SOOL
Malvastrum coromandelianum	1						1	false mallow	threelobe false mallow	a	h	MACO6
Leonotis nepetifolia	1						1	lion's ear	Christmas candlestick	a	h	LENE
Amaranthus spinosus	1						1	spiny amaranth	spiny amaranth	a	h	AMSP
Kyllinga brevifolia	5						5		shortleaf spikesedge	a	g	KYBR
Saccharum spontaneum			tr				tr	wild sugarcane	wild sugarcane	a	g	SASP
Axonopus fissifolius	20						20	narrowleaf carpetgrass	common carpetgrass	a	g	AXFI
Sporobolus indicus	1						1	smut grass	smut grass	a	g	SPIN4
Urochloa maxima		20					20	guineagrass	guineagrass	a	g	URMA3
Pennisetum clandestinum	1						1	kikuyugrass	kikuyugrass	a	g	PECL2
Chloris gayana	1						1	Rhodes grass	Rhodes grass	a	g	CHGA2
Digitaria sanguinalis	1						1		hairy crabgrass	a	g	DISA
Digitaria setigera	1						1		East Indian crabgrass	a	g	DISE6
Eleusine indica	1						1	wiregrass	Indian goosegrass	a	g	ELIN3
Melinis repens	1						1	Natal redtop	rose Natal grass	a	g	MERE9
Andropogon virginicus	5						5	broomsedge	broomsedge bluestem	a	g	ANVI2
Schizachyrium condensatum	5						5	beardgrass	Colombian bluestem	a	g	SCCO10
Setaria parviflora	5						5	yellow foxtail	marsh bristlegrass	a	g	SEPA10
Paspalum urvillei	1	1					1	Vasey grass	Vasey's grass	a	g	PAUR2
Paspalum conjugatum	20						20	hilograss	hilograss	a	g	PACO14

Composite representation of State 2, Plant Community 3, Poor Condition Pasture.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Grasslike	80	20					100					
Native Forbs												
Exotic Forbs	5						5					
Native Vines/Epiphytes												
Exotic Vines	1	1					1					
Small ferns	1						1					
Native Shrubs												
Exotic Shrubs	tr	1	1				1					
Native Trees												
Tree ferns (native)												
Exotic Trees & tree ferns	1	1	1				1					
Lichen												
Moss (on ground & logs)												
Moss (on trees)												
Logs on ground (>4" dia.)												
Litter (not logs)	50						50					
Surface rocks (>3" dia.)												
Surface rocks (≤3" dia.)												
Bare Soil	5						5					

State 2, Plant Community 3, Poor Condition Pasture.

Plant Community 4 – Weedy Pasture

Weedy Pasture is dominated by low-value forage species such as Hilograss, narrowleaf carpetgrass, broomsedge, and beardgrass. Alien blackberries, shrubs such as sourbush, and forbs such as spiny amaranth occupy much of the site. Small tree species and saplings of large tree species have become common.

Pathways from this plant community

To Plant Community 2, Good Condition Pasture, via "C&F":

C = weed control; F = prescribed grazing.

Weedy Pasture can be converted to Good Condition Pasture by a combination of weed control and prescribed grazing Weeds such as alien blackberries, sourbush, and spiny amaranth are not controllable by domestic livestock and must be killed with herbicide. The grazing prescription will require removal of livestock from the pasture until guineagrass has reestablished adequately to support grazing. Thereafter, the grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing.

Composite representation of State 2, Plant Community 4, Weedy Pasture.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Psidium guajava	1	1	10				10	common guava	guava	a	t	PSGU
Schefflera actinophylla	tr	1					1	octopus tree	octopus tree	a	t	SCAC2
Falcataria moluccana	tr	tr	1				1	albizia	peacocksplume	a	t	FAMO
Schinus terebinthifolius	tr	1	5				5	christmasberry	Brazilian peppertree	a	t	SCTE
Spathodea campanulata	tr	tr	1				1	African tuliptree	African tuliptree	a	t	SPCA2
Acacia confusa	tr	tr	1				1		Formosan koa	a	t	ACCO
Lantana camara	1	5	1				5	lantana	lantana	a	s	LACA2
Pluchea carolinensis	tr	5	1				5	sourbush	cure for all	a	s	PLCA10
Ricinus communis	tr	1	1				1	castor bean	castor bean	a	s	RICO3
Rubus argutus	tr	1	1				1	Florida blackberry	sawtooth blackberry	a	v	RUAR2
Rubus rosifolius	tr	1	1				1	thimbleberry	West Indian raspberry	a	v	RURO
Nephrolepis multiflora	1						1	scaly swordfern	scaly swordfern	a	f	NEHI
Ageratina riparia	1						1	Hamakua pamakani	spreading snakeroot	a	h	AGRI2
Asclepias physocarpa	tr	1	1				1	balloonplant	balloonplant	a	h	ASPH2
Chamaecrista nictitans	1						1	partridge pea	partridge pea	a	h	CHNI2
Mimosa pudica	1						1	sensitiveplant	shameplant	a	h	MIPU8
Commelina diffusa	1						1	honohono	climbing dayflower	a	h	CODI5
Crotalaria pallida var. obovata	1	1					1	smooth rattlepod	smooth rattlebox	a	h	CRPAO
Emilia sonchifolia	1						1	Flora's paintbrush	lilac tasselflower	a	h	EMSO
Sonchus oleraceus	1						1	pualele	common sowthistle	a	h	SOOL
Malvastrum coromandelianum	1	1					1	false mallow	threelobe false mallow	a	h	MACO6
Leonotis nepetifolia	1						1	lion's ear	Christmas candlestick	a	h	LENE
Amaranthus spinosus	1	5					5	spiny amaranth	spiny amaranth	a	h	AMSP
Kyllinga brevifolia	5						5		shortleaf spikesedge	a	g	KYBR
Axonopus fissifolius	20						20	narrowleaf carpetgrass	common carpetgrass	a	g	AXFI
Sporobolus indicus	1						1	smut grass	smut grass	a	g	SPIN4
Urochloa maxima		5					5	guineagrass	guineagrass	a	g	URMA3
Chloris gayana	1						1	Rhodes grass	Rhodes grass	a	g	CHGA2
Digitaria sanguinalis	1						1		hairy crabgrass	a	g	DISA
Digitaria setigera	1						1		East Indian crabgrass	a	g	DISE6
Eleusine indica	1						1	wiregrass	Indian goosegrass	a	g	ELIN3

Composite representation of State 2, Plant Community 4, Weedy Pasture.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Melinis repens	1						1	Natal redtop	rose Natal grass	a	g	MERE9
Andropogon virginicus	5	10					10	broomsedge	broomsedge bluestem	a	g	ANVI2
Schizachyrium condensatum	5	10					10	beardgrass	Colombian bluestem	a	g	SCCO10
Setaria parviflora	5						5	yellow foxtail	marsh bristlegrass	a	g	SEPA10
Paspalum urvillei	1	1					1	Vasey grass	Vasey's grass	a	g	PAUR2
Paspalum conjugatum	20						20	hilograss	hilograss	a	g	PACO14
Grasslike	60	30					80					
Native Forbs												
Exotic Forbs	5	5	1				10					
Native Vines/Epiphytes												
Exotic Vines	tr	1	1				1					
Small ferns	1						1					
Native Shrubs												
Exotic Shrubs	1	10	1				10					
Native Trees												
Tree ferns (native)												
Exotic Trees & tree ferns	1	1	10				10					
Lichen												
Moss (on ground & logs)												
Moss (on trees)												
Logs on ground (>4" dia.)												
Litter (not logs)	40						40					
Surface rocks (>3" dia.)												
Surface rocks (≤3" dia.)												
Bare Soil	10						10					

State 2, Plant Community 4, Weedy Pasture.

State 3 – Tree Plantation

Plant Community 5

Tree Plantations in this ecological site are primarily eucalyptus plantations that have been established on old sugarcane lands. Guineagrass is often abundant beneath the trees. Strawberry guava is a common understory weed.

Composite representation of State 3, Plant Community 5, Tree Plantation.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Eucalyptus sp.	tr	1	1	1	90	5	90	eucalyptus	gum	a	t	EUCAL
Psidium cattleianum	tr	tr	tr				tr	waiawi	strawberry guava	a	t	PSCA
Clidemia hirta	tr							Koster's curse	soapbush	a	s	CLHI3
Hedychium gardnerianum	tr	tr					tr	kahili ginger	Kahila garland-lily	a	h	HEGA
Rubus rosifolius	tr						tr	thimbleberry	West Indian raspberry	a	v	RURO
Nephrolepis multiflora	1						1	scaly swordfern	scaly swordfern	a	f	NEHI
Urochloa maxima	10	10					10	guineagrass	guineagrass	a	g	URMA3
Microlaena stipoides	1						1	meadow ricegrass	weeping grass	a	g	MIST
Paspalum conjugatum	1						1	hilograss	hilograss	a	g	PACO14
Grasslike	10	10					20					
Native Forbs												
Exotic Forbs	tr	tr					tr					
Native Vines/Epiphytes												
Exotic Vines	tr						tr					
Small ferns	1						1					
Native Shrubs												
Exotic Shrubs	tr						tr					
Native Trees												
Tree ferns (native)												
Exotic Trees & tree ferns	tr	1	1	1	90	5	90					
Lichen												
Moss (on ground & logs)												
Moss (on trees)	1						1					
Logs on ground (>4" dia.)	1						1					
Litter (not logs)	80						80					
Surface rocks (>3" dia.)	1						1					
Surface rocks (≤3" dia.)	1						1					
Bare Soil	5						5					

State 3, Plant Community 5, Tree Plantation with Alien Understory.

State 4 – Native Forest with Alien Understory

Plant Community 6

This plant community has an intact or diminished overstory of large ohia and/or koa trees with a dense understory of alien shrubs, ferns, grasses, and/or small trees. Native species are unable to regenerate in this plant community and eventually die out. With time, large alien tree species would probably emerge to form a new overstory.

Pathways from this state/plant community

To State 1, Native Wet Forest, via "C&D&M":

C = weed control; D = native plant restoration; M = ungulate exclusion.

It is possible to recreate a plant community resembling Native Forest from Native Forest with Alien Understory. Before restoration of native plants, alien understory plants must be eliminated by weed control and brush management practices, and ungulates must be excluded from the restoration site. Native species that have been eliminated or greatly reduced in numbers must be restored by replanting.

To State 2, Pasture, via "A&B&C":

A = mechanical land clearing; B = pasture establishment; C = weed control.

Pasture may be created from Native Forest with Alien Understory by mechanical clearing of weedy and remnant native understory plants; native overstory trees may be harvested for timber, destroyed, or left for shade. If leaving large native trees for shade, care must be taken to not damage roots within about 20 feet of the trees. Introduced pasture grasses may then be seeded or sprigged into the site. Herbicide applications will be necessary before and during pasture establishment to control reemerging weed species.

To State 5, Weedy Forest with Alien Understory, via "J":
J = loss of native plant regeneration.
The large, mature native ohia and koa trees that form the overstory of Native Forest with Alien Understory are unable to successfully regenerate due to the very dense, shady weed understory. Eventually the large native trees die and are replaced by more competitive large alien tree species.

Composite representation of State 4, Plant Community 6, Native Forest with Alien Understory.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Metrosideros polymorpha					10		10	'ohi'a lehua	'ohi'a lehua	n	t	MEPO5
Acacia koa					10		10	koa	koa	n	t	ACKO
Psychotria sp.	tr	tr	tr	tr			1	kopiko	wild coffee	n	t	PSYCH
Psidium cattleianum	1	5	10	20			30	waiawi	strawberry guava	a	t	PSCA
Ficus sp.	tr	tr	tr	tr	tr		tr	strangler fig	fig	a	t	FICUS
Cibotium glaucum			1	1			1	hapu`u	hapu`u	n	tf	CIGL
Cibotium menziesii			tr	1			1	hapu`u `i`i	hapu`u li	n	tf	CIME8
Cyathea cooperi	tr	tr	tr				tr	Australian tree fern	Cooper's cyathea	a	tr	CYCO18
Clidemia hirta	1	1					1	Koster's curse	soapbush	a	s	CLHI3
Peperomia sp.	tr						tr	`ala`ala wai nui	peperomia	n	h	PEPER
Hedychium gardnerianum	1	1					1	kahili ginger	Kahila garland-lily	a	h	HEGA
Polygonum punctatum	1						1	water smartweed	dotted smartweed	a	h	POPU5
Freycenetia arborea	tr						tr	`ie`ie	`ie`ie	n	v	FRAR
Passiflora mollissima	1						1	banana poka	banana passionflower	a	v	PAMO5
Dicranopteris linearis	tr						tr	uluhe	Old World forkedfern	n	f	DILI
Lepisorus thunbergianus	tr						tr	pakahakaha	weeping fern	n	f	LETH6
Psilotum nudum	tr						tr	moa	whisk fern	n	f	PSNU
Setaria palmifolia	tr						tr	palmgrass	palmgrass	a	g	SEPA6
Axonopus fissifolius	1						1	narrowleaved carpetgrass	common carpetgrass	a	g	AXFI
Microlaena stipoides	1						1	meadow ricegrass	weeping grass	a	g	MIST
Grasslike	1						1					
Native Forbs	tr						tr					
Exotic Forbs	1	1					1					
Native Vines/Epiphytes	tr						tr					
Exotic Vines	1						1					
Small ferns	1						1					
Native Shrubs												
Exotic Shrubs	1	1					1					
Native Trees	tr	tr	tr	tr	20		20					
Tree ferns (native)			1	1			1					
Exotic Trees & tree ferns	1	5	10	20	tr		30					
Lichen												
Moss (on ground & logs)	10						10					
Moss (on trees)	20						20					
Logs on ground (>4" dia.)	5						5					
Litter (not logs)	70						70					
Surface rocks (>3" dia.)	1						1					
Surface rocks (≤3" dia.)	1						1					
Bare Soil	5						5					

Understory species canopy cover under a range of overstory canopy covers in Native Forest with Alien Understory.

Common Name	Scientific Name	Understory Species Canopy Cover as a function of Overstory Canopy Cover		
		Overstory Canopy Cover Percent		
		30	***60***	***90***
strawberry guava	*Psidium cattleianum*	90	90	90
common guava	*Psidium guajava*	50	40	5
christmasberry	*Schinus terebinthifolius*	90	60	5
guineagrass	*Urochloa maxima*	80	50	10
meadow ricegrass	*Microlaena stipoides*	20	30	70

State 4, Plant Community 6, Native Forest with Alien Understory.

State 5 – Weedy Alien Forest

Plant Community 7

This state is comprised of one plant community dominated by alien species in both the overstory and understory. Strawberry guava, christmasberry, or common guava may dominate a given site, but strawberry guava will become dominant with time. Understory vegetation usually is very sparse to nonexistent. Remnant, tall koa or ohia trees may be present. Native kopiko trees and tree ferns may still occur in very small numbers.

Pathways from this state/plant community

To State 2 – Pastures, via "A&B&C":

A = mechanical land clearing; B = pasture establishment; C = weed control.

Pasture may be created from Weedy Forest with Alien Understory by mechanical clearing of overstory and understory vegetation. Introduced pasture grasses may then be seeded or sprigged into the site. Herbicide applications will be necessary before and during pasture establishment to control reemerging weed species.

Composite representation of State 5, Plant Community 7, Weedy Alien Forest.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Metrosideros polymorpha					tr		tr	'ohi'a lehua	'ohi'a lehua	n	t	MEPO5
Acacia koa					tr		tr	koa	koa	n	t	ACKO
Psychotria sp.	tr	tr	tr	tr			tr	kopiko	wild coffee	n	t	PSYCH
Psidium cattleianum	1	10	30	30			70	waiawi	strawberry guava	a	t	PSCA
Psidium guajava		tr	1	1			1	common guava	guava	a	t	PSGU
Schinus terebinthifolius			1	1			1	christmasberry	Brazilian peppertree	a	t	SCTE
Morella faya			1	1			1	faya tree	firetree	a	t	MOFA
Cibotium glaucum			tr				tr	hapu`u	hapu`u	n	tf	CIGL
Clidemia hirta	1	1					1	Koster's curse	soapbush	a	s	CLHI3
Hedychium gardnerianum	1	1					1	kahili ginger	Kahila garland-lily	a	h	HEGA
Polygonum punctatum	1						1	water smartweed	dotted smartweed	a	h	POPU5
Passiflora mollissima	1						1	banana poka	banana passionflower	a	v	PAMO5
Dicranopteris linearis	tr						tr	uluhe	Old World forkedfern	n	f	DILI
Setaria palmifolia	tr						tr	palmgrass	palmgrass	a	g	SEPA6
Axonopus fissifolius	1						1	narrowleaved carpetgrass	common carpetgrass	a	g	AXFI
Microlaena stipoides	1						1	meadow ricegrass	weeping grass	a	g	MIST
Grasslike	1						1					
Native Forbs												
Exotic Forbs	1	1					1					
Native Vines/Epiphytes												
Exotic Vines	1						1					
Small ferns	tr						tr					
Native Shrubs												
Exotic Shrubs	1	1					1					
Native Trees	tr	tr	tr	tr	tr		tr					
Tree ferns (native)			tr				tr					
Exotic Trees & tree ferns	1	5	20	20			50					
Lichen												
Moss (on ground & logs)	5						5					
Moss (on trees)	10						10					
Logs on ground (>4" dia.)	tr						tr					
Litter (not logs)	70						70					
Surface rocks (>3" dia.)	1						1					
Surface rocks (≤3" dia.)	1						1					
Bare Soil	5						5					

State 5, Plant Community 7, Weedy Alien Forest.

ECOLOGICAL SITE INTERPRETATONS

Forest Site Productivity

Common Name	Scientific Name	Estimated Productivity						
		Site Index		Cubic Feet (CMAI)		Other Units		
		Low	High	Low	High	Low	High	Unit
`ohi`a lehua	*Metrosideros polymorpha*					**800**	**2000**	**cu. ft./ac**
koa	*Acacia koa*					**1500**	**3700**	**cu.ft./ac**

Animal Community

Animal Community – Wildlife Interpretations

This site provides habitat to a variety of small, medium-sized, and large introduced birds such as doves, wild turkey, ring-necked pheasant, Eurasian skylark, Erckel's francolin, black francolin, and khalij pheasant. States that provide open grassland or savannah-like settings provide habitat for other important wildlife such as the Hawaiian hawk and the Hawaiian owl. This site can also provide habitat to the following native birds: Hawaii elepaio, omao, Hawaii amakihi, apapane, iiwi, Hawaiian crow, ou, Hawaii akepa, akiapolaau, as well as the Hawaiian hoary bat. Feral pigs, sheep, and cattle are very common; they provide hunting opportunities but are very destructive to the native vegetation.

Animal Community – Grazing Interpretations

The following table lists suggested initial stocking rates for cattle under the Forage Value Rating system for only State 2, Plant Community 2, Good Condition Pasture, with guineagrass. For kikuyugrass pastures on this ecological site, refer to grazing interpretations in Ecological Site Description F160XY502HI – Mauna Kea Koa-Mamane. The following are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Sometimes the current plant composition does not entirely match any particular plant community described in this ecological site description. Because of this, a field visit is recommended to document plant composition and production. More precise carrying capacity estimates should eventually be calculated using the following stocking rate information along with animal preference data, particularly when grazers other than cattle are involved. Under more intensive grazing management, improved harvest efficiencies may result in an increased stocking rate.

Forage Value Rating [1/]	Acre/AUM [3/]	AUM/Acre [3/]
Very High [2/]	0.20 – 0.22	5.13 – 4.49
High	0.22 – 0.26	4.49 – 3.85
Moderate	0.26 –0.39	3.85 –2.56
Low	0.39 - +	2.56 - +

1/ The Forage Value Rating System is not an ecological evaluation of State 2, Plant Community 2, Good Condition Pasture. It is a utilitarian rating of the existing forage value for that specific plant community.
2/ Conservationists must use considerable judgment, because some pastures in the Very High forage class could be producing less than normal volumes of forage, and adjustments would need to be made in the initial stocking rate.
3/ Stocking rates vary in accordance with such factors as kind and class of livestock or wildlife, season of use, harvest efficiency and fluctuations in climate. Figures shown are calculated assuming a 30% adjustment factor to account for harvest efficiency and the "take half – leave half" principle. Actual use records and on-site inventories for individual sites, together with a determination of the degree to which the sites have been grazed, offer the most reliable basis for developing initial stocking rates.

The Good Condition Pasture plant community on this site is suitable for grazing by all kinds and classes of livestock, at any season, particularly cattle. However, this site is best utilized for grazing during the major plant growth period described in the "Climate" section. This site is suited for grazing by both cow-calf operations and stocker operations. However, sheep can be grazed on this site as well. This site is poorly suited to continuous year-long use if the Good Condition Pasture plant community is to be maintained. Herbaceous forage can be deficient in protein during the drier months.

Plant Preference for Cattle

Common Name	Scientific Name	Plant Part	Forage Preferences											
			J	F	M	A	M	J	J	A	S	O	N	D
Guineagrass	*Urochloa maxima*	entire	P	P	P	P	P	P	P	P	P	P	P	P
Napier elephantgrass	*Pennisetum purpureum*	entire	P	P	P	P	P	P	P	P	P	P	P	P
Kikuyugrass	*Pennisetum clandestinum*	entire	P	P	P	P	P	P	P	P	P	P	P	P
Pangolagrass	*Digitaria eriantha*	entire	P	P	P	P	P	P	P	P	P	P	P	P
Smutgrass	*Sporobolus indicus*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Hilograss	*Paspalum conjugatum*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Narrowleaf carpetgrass	*Axonopus fissifolius*	entire	U	U	U	U	U	U	U	U	U	U	U	U
East Indian crabgrass	*Digitaria setigera*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Hairy crabgrass	*Digitaria sanguinalis*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Natal redtop	*Melinis repens*	entire	D	D	D	D	D	D	D	D	D	D	D	D
Rhodesgrass	*Chloris gayana*	entire	D	D	D	D	D	D	D	D	D	D	D	D
Broomsedge bluestem	*Andropogon virginicus*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Bushybeard bluestem	*Schizachyrium condensatum*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Wiregrass	*Eleusine indica*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Yellow foxtail	*Setaria firmula*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Green kyllinga	*Cyperus brevifolius*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Vaseygrass	*Paspalum urvillei*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Glycine	*Neonotonia wightii*	entire	P	P	P	P	P	P	P	P	P	P	P	P
Three-flowered tickletrefoil	*Desmodium triflorum*	entire	D	D	D	D	D	D	D	D	D	D	D	D
Japanese tea	*Chamaecrista nictitans*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Sensitive plant	*Mimosa pudica*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Smooth rattlepod	*Crotalaria pallida var. obovata*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Common sowthistle	*Emilia sonchifolia*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Lion’s ear mint	*Leonotis nepetifolia*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Spiny amaranth	*Amaranthus spinosus*	entire	N	N	N	N	N	N	N	N	N	N	N	N
Bush indigo	*Indigofera suffruticosa*	entire	D	D	D	D	D	D	D	D	D	D	D	D
Sourbush	*Pluchea carolinensis*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Christmasberry	*Schinus terebinthifolius*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Thimbleberry	*Rubus rosifolius*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Balloonplant	*Asclepias physocarpa*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Castor bean	*Ricinum communis*	entire	T	T	T	T	T	T	T	T	T	T	T	T

Legend: P=Preferred, D=Desirable, U=Undesirable, N=Not Consumed, E=Emergency, T=Toxic, X=Used, but degree of utilization unknown.

Hydrology Functions

Recreation Uses

Hunting is the most common recreational use.

Wood Products

There is good potential for production of timber in this ecological site, including eucalyptus and high-value specialty woods such as koa. However, there has been very little utilization of the resource to date.

Other Products

Other Information

SUPPORTING INFORMATION

Associated Sites

Site Name	Site ID	Site Narrative

Similar Sites

Colloquial Site Name	Site ID	Site Narrative
Ohia-Koa/Hapu`u-Kanawao Forest	F159BY500HI	Similar wet forest on younger ash soils in Kau District.

State Correlation

There are no correlations to ecological sites in other states.

Inventory Data References

	Sample ID			
Data Source	**Number**	**Year**	**State (FIPS)**	**County (FIPS)**
HI Forest ESD field sheet	1	2008	HI	Hawaii
HI Forest ESD field sheet	2	2007	HI	Hawaii
HI Forest ESD field sheet	17	2006	HI	Hawaii
HI Forest ESD field notes	1	2008	HI	Hawaii
HI Forest ESD field notes	4	2006	HI	Hawaii
NRCS-Range-417	1	2001-2003	HI	Hawaii
Hawaii-Range-1	7	2001-2003	HI	Hawaii

Type Locality

	Site #1 (NAD83 datum)	Site #2	Site #3
Latitude:	N19d55m59.4s		
Longitude:	W155d17m25.6s		
State:	HI		
County:	Hawaii		
General Description:	Hawaii County, Island of Hawaii, USGS Quad: Keanakolu. From main (highest) Laupahoehoe NAR gate, drive mauka 2.5 miles. Walk W 100 yards into forest.		

Relationship to Other Established Classifications

1.	Jacobi, J.D. 1989. Vegetation Maps of the Upland Plant Communities on the Islands of Hawai`i, Maui, Moloka`i, and Lana`i. Technical Report 68. Cooperative National Park Resources Studies Unit, University of Hawai`i at Manoa and National Park Service.
2.	Ripperton, J.C. and E.Y. Hosaka. 1942. Vegetation zones of Hawai`i. Hawai`i Agricultural Experiment Station Bulletin 89:1-60.
3.	U.S. Dept. of Interior-U.S. Geological Survey. 2006. A GAP Analysis of Hawai`i. Final Report and Data.

Other References

1.	Armstrong, R.W. 1973. Atlas of Hawai`i. University of Hawai`i Press, Honolulu.
2.	Maly, K. and O. Maly. 2004. A Cultural Study of the Pu`u O `Umi Natural Area Reserve and Kohala-Hamakua Mountain Lands, Districts of Kohala and Hamakua, Island of Hawaii. Kumu Pono Associates LLC, Hilo, HI.
3.	Mueller-Dombois, D. and F.R. Fosberg. 1998. Vegetation of the Tropical Pacific Islands. Springer-Verlag New York, Inc.
4.	Palmer, D.D. 2003. Hawai`i's Ferns and Fern Allies. University of Hawai`i Press, Honolulu.
5.	Pratt, H.D. 1998. A Pocket Guide to Hawai`i's Trees and Shrubs. Mutual Publishing, Honolulu.
6.	Rock, J.F. The Indigenous Trees of the Hawaiian Islands. 1st edition 1913, reprinted 1974, Charles E. Tuttle Company, Rutland, VT and Tokyo, Japan.
7.	Sohmer, S.H. and R. Gustafson. 2000. Plants and Flowers of Hawai`i. University of Hawai`i Press, Honolulu.
8.	Wagner, WL, DR Herbst, and SH Sohmer. 1990. Manual of the Flowering Plants of Hawai`i. Bishop Museum Special Publication 83, University of Hawaii Press, Honolulu.

Site Description Approval

Author	Date	Approval	Date
David Clausnitzer	**07/07/2008**	**David Clausnitzer**	**07/07/2008**
Joseph May	**2003**		
Loretta J. Metz	**07/07/2008**	**Loretta J. Metz**	**07/07/2008**

BEST MANAGEMENT PRACTICES

FOR

MAINTAINING WATER QUALITY

IN HAWAII

State of Hawaii
Department of Land and Natural Resources
Division of Forestry and Wildlife
February 1996

FOREWORD

Best Management Practices (BMPs) are effective, practical, structural or nonstructural methods which prevent or reduce the movement of sediment, nutrients, pesticides and other pollutants from the land to surface or ground water, or which otherwise protect water quality from potential adverse effects of silvicultural activities. These practices are developed to achieve a balance between water quality protection and the production of wood crops within natural and economic limitations.

A thorough understanding of BMPs and the flexibility in their application are of vital importance in selecting BMPS which offer site specific control of potential nonpoint source pollution. With each situation encountered at various sites, there may be more than one correct BMP for reducing or controlling potential nonpoint source pollution. Care must also be taken to select BMPs that are practical and economical while maintaining both water quality and the productivity of forest land.

The Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500 (and as amended by Sec. 319, 1986), require the management of nonpoint sources of water pollution from sources including forest-related activities. BMPs have been developed to guide forest landowners, other land managers and timber harvesters toward voluntary compliance with this act. Maintenance of water quality to provide "fishable" and "swimmable" waters is central to this law's objectives. The Environmental Protection Agency (EPA) recognizes the use of BMPs as an acceptable method of reducing nonpoint source pollution.

Nonpoint source is diffuse pollution that comes from almost everywhere; it even occurs naturally to a certain extent. The amount of pollutants from any particular spot is small and insignificant, but when combined from over the landscape, can create water quality problems. **Although it is unrealistic to expect that all nonpoint source pollution can be eliminated, BMPs can be used to minimize the impact of forestry practices on water quality. These practices must be reasonable, achievable and cost effective.** The adoption and use of BMPs will provide the mechanism for attaining the following water quality goals:

* to maintain the integrity of stream courses;

* to reduce the volume of surface runoff originating from an area of forest management disturbance and running directly into surface water;

* to minimize the movement of pollutants i.e. pesticides, nutrients, petroleum products, etc. and sediment to surface and ground water;

* to stabilize exposed mineral soil areas through natural or artificial revegetation means.

The intent of this guide is to promote better stewardship of the forest resources. This guide delineates environmentally responsible land management methods which, when applied properly, minimizes adverse impacts on the forest ecosystem and maximizes landowner objectives. Unusual situations may arise or pollution control measures other than those recommended here may be found. In these cases, common sense is most often the best guide.

Information presented in this guide is not to be used as the basis for setting water quality standards or as the basis of required use of watershed protection practices. Compliance with any watershed protection practices would be on a voluntary basis backed up with a public water quality education and awareness program. Changing of water quality standards or the required use of protection practices should not be attempted without careful study of the beneficial effects gained from modifying existing silvicultural practices now in use.

INTRODUCTION

The Division of Forestry and Wildlife (DOFAW) is mandated by HRS, Chapter 183 to "...devise ways and means of protecting, extending, increasing, and utilizing the forests and forest reserves, more particularly for protecting and developing the springs, streams, and sources of water supply to increase and make that water supply available for use..."

The number one resource that is generated by the forest is water. Since the establishment of the Department of Agriculture and Forestry in 1900, the concern for the protection of forest lands for the purpose of water has been a high priority. Fencing to keep out wild cattle and other feral animals and reforestation efforts to re-establish watersheds have been the key to the continuance of the production of high quality water.

In 1961, Hawaii created, by law, the nation's first statewide zoning districts, and today approximately 95% of the Hawaii's four million acres are zoned for agricultural or conservation uses. The Conservation district, which is under the jurisdiction of the Department of Land and Natural Resources (DLNR), encompasses almost one-half of the State, of which one million acres is state-owned. The majority of Conservation lands are covered by forests, but also contain grasslands, coastlines, cliffs, offshore islets, and wetlands. Vegetative communities include lowland and montane rainforests and unique examples of tropical biodiversity, much of it endangered.

The Division of Forestry and Wildlife recognizes the need for responsible stewardship of the natural resources, which include soil and water. **The success of BMPs to protect water quality within Hawaii depends on mutual cooperation and trust among landowners, industry, environmentalists, wood producers, regulatory agencies, governmental officials, and the general public.** All have an interest in good land management as it relates to water quality.

THE FOREST/WATER RELATIONSHIP

The forest and water resources are mutually dependent upon one another. Forests depend on water, namely rain, surface water, and groundwater for their growth and reproduction. Major long-term changes in the water supply can cause permanent changes in the content, quality and vitality of forest lands.

On the other hand, surface and groundwater quantity and quality are largely influenced by the surface on which rain falls and through which it percolates. The tremendous filtering capacity of forest lands provide effective and high quality groundwater recharge.

Hawaii's streams and aquifers all benefit from the presence of forests. In addition to these water quality benefits, forests provide needed wood and fiber products, wildlife habitat, aquatic resources and habitat, recreation values and aesthetic benefits. It is in managing forests for these benefits that damage to the water resource can result. Following is a brief discussion of the most commonly used forest management practices and the impacts they can have on the quality of the water resource.

Timber Harvesting

The removal of trees from a site has little impact on water quality, as long as the trees do not provide vital shade to streams and as long as the slope of the land is not excessive. The natural warmth of many streams can be exaggerated by removing shading vegetation from their banks. Increased water temperature promotes lower dissolved oxygen levels, placing stress on fish and other aquatic organisms.

Removing timber per se does not directly cause significant water quality changes, since ground cover is not excessively disturbed during proper logging operations. On steep slopes, however, careless timber removal can increase the likelihood of runoff and soil loss. This may lead to water quality degradation as well as a loss of site productivity. Steep areas should therefore be logged carefully using proper harvesting techniques for the sake of both water quality protection and site protection.

Road Construction and Drainage Techniques

All facets and phases of a sound forest management program rely heavily on accessibility to the forest. Consequently, temporary and permanent access roads are necessary components of all management programs. They are also one of the most costly investments made in a forests.

Temporary access roads are constructed to facilitate harvesting operations, site preparation and planting and often abandoned after the new stand is established. When abandoned, these temporary roads are normally allowed to revegetate naturally or are planted with trees.

Pollutants from Silvicultural Activities

The major types of water pollutants that can be generated from forest management disturbances to the forest ecosystem include sediment, nutrients, pesticides, and debris.

1) Sediment

Sediment is the most common pollutant resulting from silvicultural activities. Sediment principally results from erosion of soil, but may also include organic matter. Excessive sediment upsets balanced ecology within streams by smothering bottom dwelling organisms in the water, interfering with photosynthesis by reducing light penetration, serving as carriers of nutrients and pesticides, inhibiting fish reproduction and altering stream flow.

2) Nutrients

Nutrients, primarily phosphorous and nitrogen fertilizers, are sometimes applied to the forest to stimulate tree growth. Soluble nutrients may reach surface or ground water through runoff, seepage, and percolation. Insoluble forms may be absorbed on soil particles and reach water by direct wash-off of debris and recently applied fertilizer. Excessive nutrients lead to an imbalance in natural life cycles of water bodies.

3) Pesticides

Pesticides, if applied during silvicultural activities, may be soluble or insoluble. Pesticides in surface or ground water may result in toxicity problems, affecting water quality and food sources for aquatic life.

4) Debris

Tree limbs, tree tops, and other waste materials are the principal organic pollutants from silviculture. They reach streams through direct pushing or felling into water drainages, and washout during storms. Organic materials may place an oxygen demand on the receiving water body during the decomposition process. In addition, associated problems may include odor, color, taste and nutrients. Inorganic material such as oil cans and pop bottles are also considered nonpoint source debris.

BEST MANAGEMENT PRACTICES

1.0 Forest Roads

Standards and Use

Forest roads are managed to provide adequate access to lands for timber management, fire suppression, wildlife habitat improvement and a variety of dispersed and developed recreational activities. Generally, these are low volume roads that must carry heavy loads for short periods of time. The potential for adverse impacts from forest roads exists in areas where steep slopes, erodible soils, or where forest roads are located near water. **Forest roads cause more erosion than any other forestry activity.** Most of this erosion can be prevented by locating, constructing, and maintaining roads to minimize soil movement and pollution of streams. The need for higher standard roads can be alleviated through better road-use management. Design roads to the minimum standard necessary to accommodate anticipated use and equipment.

Planning, Design, and Location

A well planned access system is a sound method of reducing erosion and sedimentation in areas requiring frequent or temporary access. Proper location and construction of roads will provide for safety, longer operating periods, lower maintenance and operating costs, and minimal impacts to water quality. The value of the resource served and site characteristics will influence the choice of road construction standards and maintenance activities. The following practices are recommended:

(1) Use a design to minimize damage to soil and water quality.

(2) Roads should be designed no wider than necessary to accommodate the immediate anticipated use.

(3) Design cut and fill slopes to minimize mass soil movement.

(4) Provide culverts, dips, water bars, and cross drainages to minimize road bed erosion.

(5) Design bridge and culvert installations using stream flow data, with a margin of safety proportional to the importance of the road and the protected resources.

(6) Provide drainage where surface and groundwater cause slope instability.

(7) Avoid diverting water from natural drainage ways. Dips, water bars, and cross drainage culverts should be placed above stream crossings so that water can be filtered through vegetative buffers before entering streams.

(8) Locate roads to fit the topography and minimize alterations to the natural features.

(9) Avoid marshes and wetlands.

(10) Minimize the number of stream crossings.

(11) Cross streams at right angles to the stream channel.

(12) A road may not be located in a Streamside Management Zone (SMZ) except where access is needed to a water crossing, or where there is no feasible alternative. A road in any SMZ must be designed and located to minimize adverse effects on fish habitat and water quality.

Construction

Once the road's location and design is staked out, road construction begins. Timber is out, logs and vegetation are removed and piled along the lower side of the right-of-way.

Most forest roads are built by excavating a road surface. Road design and layout on-the-ground show machine operators the proper cut slopes and indicate cut slope steepness. The bulldozer starts at the top of the cut slope, excavating and sidecasting material until the desired road grade and width is obtained. Material from cuts is often pushed in front of the blade to areas where fill is needed. Road fill is used to cover culverts and build up flat areas. Since fill must support traffic, it needs to be spread and compacted in layers to develop strength. The following practices are recommended:

(1) Construct roads when moisture and soil conditions are not likely to result in excessive erosion or soil movement.

(2) The boundaries of all SMZs shall be defined on the ground prior to the beginning of any earth-moving activity.

(3) Construct a road sufficient to carry the anticipated traffic load with reasonable safety and with minimum environmental impact.

(4) When using existing roads, reconstruct only to the extent necessary to provide adequate drainage and safety.

(5) Avoid construction during wet periods, when possible, to minimize unnecessary soil disturbance and compaction.

(6) Road grades should be kept at less than 10%, except where terrain requires short, steep grades.

(7) Minimize the number of stream crossings. Stream crossing construction should minimize disturbance of the area in which the crossing is being constructed.

(8) As slope increases, additional diversion ditches should be constructed to reduce the damages caused by soil erosion; ditches, adequate culverts, cross drains, etc., should be installed concurrent with construction.

(9) To control erosion, cut and fill slopes should conform to a design appropriate for the particular soil type and topography.

(10) Stumps, logs, and slash should be disposed of outside of the road prism; in no cases should they be covered with fill material and incorporated into road beds.

(11) Stabilize the side banks of a road during construction to aid in the control of erosion and road deterioration; this may require mesh or other stabilizing material in addition to planting and/or seeding and other structural measures.

(12) Water bars should be located to take advantage of existing wing ditches and cross drainage. Water bars should be constructed at an angle of 30 to 45 degrees to the road. Water bars should be periodically inspected and damage or breeches should be promptly corrected. Install water bars at recommended intervals to provide the drainage. Water bar spacing recommendations are as follows:

Grade of Road	Distance Between Water bars
2%	250 ft.
5%	135 ft.
10%	80 ft.
15%	60 ft.
20%	45 ft.
25%	40 ft.
30%	35 ft.
40%	30 ft.

Water bars may need to be spaced closer together depending on soil type and rainfall.

(13) Bridges and overflow culverts should be constructed to minimize changes in natural stream beds during high water.

(14) Culverts on perennial streams should be installed low enough to allow passage of aquatic life during low water.

Maintenance

Maintenance of active and inactive roads shall be sufficient to maintain a stable surface, keep the drainage system operating, and protect the quality of streams. The following are recommended:

(1) Maintenance should include cleaning dips and crossdrains, repairing ditches, marking culverts inlets to aid in location, and clearing debris from culverts.

(2) Keep culverts, flumes, and ditches functional before and during the rainy season to diminish danger of clogging and the possibility of washouts. This can be done by clearing away any sediment or vegetation that could cause a problem. Provide for practical and scheduled preventative maintenance programs for high risk sites that will address the problems associated with high intensity rainfall events.

(3) Conduct road surface maintenance as necessary to minimize erosion of the surface and subgrade.

(4) During operations, keep the road surface crowned or outsloped, and keep the downhill side of the road free from berms except those intentionally constructed for protection of fill.

(5) Avoid using roads during wet periods if such use would likely damage the road drainage features.

(6) Water bars should be inspected after major rain storms and damage or breeches should be promptly corrected.

Harvesting - Temporary Access Roads and Landings

(1) The location of temporary access roads (logging roads) should be planned before operations begin.

(2) Road construction should be kept to a minimum.

(3) Landings should be located to minimize the adverse impact of skidding on the natural drainage pattern.

(4) Logging roads and landings should be located on firm ground.

(5) Landings should be kept as small an area as possible.

(6) When operations are completed, provisions should be made to divert water run-off from the landings and roads.

2.0 Pre-Harvest Planning

Pre-harvest planning is the collection of information about the area to be harvested and the synthesis of that information into an effective environmental plan. This plan will consider the silvicultural prescription for the species and site, the best estimate of the time and method of harvest and any post-harvest site preparation and reforestation activities.

At this stage, it is assumed that all federal, state, and local government regulations regarding harvesting have been met.

An effective pre-harvest plan will take into consideration all aspects of the timber harvest which may lead to water quality degradation and plan for the implementation of BMPs which will minimize or avoid the adverse effects of the operation. The objective of pre-harvest planning from the perspective of non-point source pollution is to determine which BMPs are necessary to protect water quality and how those BMPs will be implemented. The following is recommended:

(1) A pre-harvest plan should include the following information:

A. Physical and administrative description

1. Property boundaries & administrative boundaries (zoning, etc.)
2. Topography
3. Location of streams and drainages
4. Location of SMZs and buffer strips
5. Forest types
6. Soil types
7. Areas of ecological and/or archaeological concerns

B. Management Activities

1. Design and construction techniques for all new roads, skid trails, and landings or modification of existing roads, skid trails and landings.
2. Felling and bucking techniques
3. Yarding systems and layout
4. Planned stream crossings
5. Disposal of waste materials (machine lubricants)
6. Post-harvest site preparation
7. Reforestation activities

(2) The use of topographic maps, road maps, aerial photos, forest type maps, and soil surveys in combination with field reconnaissance is essential to determine site conditions and plan operations.

(3) Field reconnaissance with a trained forester or one who is knowledgeable about the specific area is highly recommended.

(4) Preliminary planning should consider the maintenance of existing drainage patterns and the location of environmentally sensitive areas such as streams, wet areas, and high erosion hazard areas.

(5) The design of roads, skid trails, and landings shall be integrated to minimize their impact.

(6) The grade of logging roads and skid trails should be less than 10% when possible, with 3-5% being the norm. Long, straight, unbroken grades are to be avoided. Adequate surface drainage shall be provided.

(7) Time the harvesting activity for the season or moisture conditions when the least impact occurs.

(8) A final pre-harvest site review shall be conducted by management so that road alignments and other considerations can be visually checked prior to road construction. The reconnaissance plan shall be modified as necessary to make desirable adjustments based on the final site review.

2.1 Timber Harvesting

Standards and use

Timber harvesting is an integral part of most forest management programs. Harvesting operations cause a temporary disturbance in the forest as well as diminish water quality. However, it can be conducted in a manner where the impact to water quality is minimized and the re-establishment of vegetative cover is realized. Guidelines to help reduce the potential for nonpoint source pollution from harvesting trees are as follows:

Felling and Bucking

(1) Careful felling can minimize the impact of subsequent phases of the logging operation.

(2) Trees should not be felled into streams, except where no safe alternative exists. In the latter case, such trees should be removed promptly.

Skidding

(1) Skidding should be done so as to avoid disrupting natural drainage and to prevent excessive soil displacement.

(2) Stream channels or road ditches should not be used as skid trails.

(3) Skid trails on steep slopes should have occasional water bars.

(4) Servicing of equipment involving fuel, lubricants, or coolants should be performed in places where these materials cannot enter streams. Spent oil should be collected for proper disposal, never poured on the ground.

(5) Upon completion of logging, erosion-prone areas should be mulched or seeded.

Mechanical Site Preparation

(1) Avoid excessive soil compaction.

(2) Minimize erosion and the movement of sediment into waters.

(3) Prevent accumulation of debris in ponds, streams, or rivers.

(4) Windrows, disking, bedding, and planting with "furrow" type mechanical planters should follow contours.

(5) Avoid complete disking of steep slopes with extremely erodible soil.

(6) Plant trees on contour.

Disposal of Debris and Litter

(1) Logging debris in streams should be removed immediately.

(2) Debris from landings should not be pushed into drains, streams or Streamside Management Zones (SMZs)

(3) All trash associated with the logging operation should be promptly removed (not buried) and hauled to a legal disposal site.

3.0 Silvicultural Chemical Management

Description and Purpose

Pesticides are used on forest lands to facilitate meeting forest management objectives. The purpose of a pesticide application is to rid an area of undesirable vegetation or control insects or diseases to promote the establishment, survival, growth or maintenance of a desired species or condition.

Planning Considerations

Planning is an essential first step in reducing pest problems. A plan is needed by which the application of pesticides is utilized in an efficient manner that produces no adverse impacts on the environment. The maintenance of water quality is an important consideration in all aspects of pesticide operation planning.

Pesticide Selection

When the decision is made to use pesticides, choose products suitable for use on the target species and registered for the intended uses. Use only pesticides registered by the Environmental Protection Agency. Prior to using any pesticide, carefully read and follow all label directions.

When selecting pesticide options, more than effectiveness and cost should be evaluated. Consideration should be given to site factors, application conditions and techniques and products that can influence impacts to water quality.

Three main characteristics can greatly affect a pesticide potential to contaminate surface or ground water. They are solubility, absorption and breakdown rate.

1) Solubility

Solubility is the ability of a pesticide to dissolve in water. The greater the solubility, the greater the chance that the chemical will leach to ground water.

2) Absorption

Absorption is the inherent ability of a pesticide to bind with soil. Some pesticides stick very tightly to soil while others are easily dislodged. A greater absorption means a pesticide will remain longer in the soil and thus be less likely to leach down into the ground water before it has degraded. Absorption increases as soil organic matter increases.

3) Breakdown Rate

Breakdown rate or half-life is the time a pesticide takes to degrade or breakdown into other chemical forms. Pesticides that do not break down quickly can be hazardous if they move to ground water or surface water.

In a given situation, pesticides with the highest water solubilities, greatest persistence, lowest affinities for absorption to organic matter and other soil components, and highest application rates have the greatest potential for movement in surface water or to ground water. An alternative means of minimizing the potential movement of a pesticide is to select a non-broadcast application

technique for the same pesticide that reduces the amount of the chemical applied directly to the soil.

Procedures for Chemical Use

Proper pesticide management practices make efficient use of chemical while preventing contamination of surface water or ground water. Residues of pesticides used in forestry can affect water quality at several phases of the chemical use cycle. These phases are: 1) transportation, 2) storage, 3) mixing and loading, 4) application, and 5) cleanup and disposal. To minimize potential impacts on water quality, use of the following practices is encouraged.

A) Transportation

(1) Inspect all containers prior to loading and ensure all caps, plugs and bungs are tightened.

(2) Handle containers carefully when loading them onto vehicles.

(3) Secure containers properly to prevent shifting during transport.

(4) Check containers periodically enroute.

(5) Limit access to containers during transport to prevent tampering.

(6) Educate and inform the driver of the proper transportation precautions.

(7) Never transport pesticides unless arrangements have been made to receive and store them properly.

B) Storage

(1) Chemicals should be managed and stored in accordance with all applicable federal, state, or local regulations. These would include:

(a) The EPA container registration label, as printed on the label;

(b) Label instruction for use as provided by the manufacturer;

(c) Requirements or the use, application, and registration of pesticides;

(d) Requirements relating to the licensing of applicators.

(2) All containers should be labeled in accordance with applicable federal, state and local regulations.

(3) Apply pesticides under favorable weather conditions. Never apply a pesticide when there is a likelihood of significant drift.

(4) Always use pesticides in accordance with label instruction, and adhere to all Federal and State policies and regulations governing pesticide use.

E) Cleanup and Disposal

(1) Before disposal, containers should be rinsed as described in equipment cleanup.

(2) Cleanup should be in a location where chemicals will not enter any stream, pond, or where stream pollution might occur.

(3) Rinse empty pesticide containers and mixing apparatus as many times as needed. This flushing should be applied in spray form to the treated area, NOT into the ground near streams.

(4) Dispose of pesticide wastes and containers according to federal and state laws. Some pesticide wastes are specifically identified as hazardous wastes by law and must be handled and disposed of in accordance with hazardous waste regulations. For more information about proper management of waste pesticides, contact the Department of Health, Environmental Health Administration.

Other chemicals

Improper storage and handling of oil products and fuel can be a water quality hazard. Improper disposal of oil or fuel can contaminate ground water and seep into streams. The following are recommended:

(1) Locate facilities away from streams and be prepared to clean up spills.

(2) Know and comply with regulations governing the storage, handling, application (including licensing of applicators), and disposal of hazardous substances.

(3) Do not transport, handle, store, load, apply or dispose of any hazardous substance or fertilizer in such a manner as to pollute water supplies or cause damage or injury to land, including humans, desirable plants and animals.

(4) Do not store, mix, or rinse hazardous substances or fertilizers within the streamside management zone or where they might enter streams or waterways.

(5) Develop a contingency plan for hazardous substance spills, including cleanup procedures.

(6) Report all spills to the Department of Health, Environmental Health Administration.

4.0 Streamside Management Zone (SMZ)

The Special Management Zone (SMZ) is a specific area associated with a stream, lake, wetland or other waterbody that is designated and maintained during silviculture operations. The purpose of the SMZ is to protect water quality by reducing or eliminating forestry related ouputs, i.e. sediment, nutrients, logging debris, chemicals, and water temperature fluctuations that can adversely affect aquatic communities. SMZs provide shade, streambank stability and erosion control, as well as detritus and woody debris which benefit the aquatic ecosystem in general. In addition, the SMZ is designed to maintain certain forest attributes that will provide specific wildlife habitat values. Snags, den and cavity trees as well as mast producing trees, left in the SMZ, are necessary to meet habitat requirements for certain wildlife.

The SMZ has specific criteria, that defines operational restrictions and special management objectives. In addition, the SMZ has a specific width which is based on the size and type of waterbody involved.

A Streamside Management Zone (SMZ) is an area covered with vegetation or ground cover on both sides of perennial, intermittent streams and other bodies of open water, where extra precaution is used in carrying out forest management practices. The SMZ also provides shade and functions as a buffer when fertilizers, pesticides, etc. are applied to adjacent lands. For practical purposes, an SMZ must be wide enough to protect water quality and stream characteristics. Precaution is needed in carrying out forest management practices in order to protect bank edges and water quality. Determining the necessary width involves in part a judgement factor based on reliable local experience.

SMZs should be used where: 1) water quality is impaired and adjacent land use contributes to that degradation, 2) good water quality exists and protection against potential future impairment is desired, 3) streambank erosion is a concern, 4) wildlife habitat enhancement is desired, and/or 5) silviculture practices are to be implemented, and 6) the lower edge of cropland, grassland, or forest land is adjacent to permanent or intermittent streams, or border streams, rivers, ponds or intermittent or permanently flooded, open-water wetlands.

SMZ benefits include the following:

(1) Shade - Trees within the SMZs provide shade to maintain cool water temperatures which aid in the spawing of fish. Without trees and overhanging shrubs, stream temperatures would increase during the summer. Some fish species and aquatic organisms would then be unable to live in the streams. In the summer, water from shaded streams eventually flows into larger bodies of water and helps maintain its fish and aquatic life by keeping these waters cool all the way downstream.

(2) Food - Leaves and insects drop into streams from overhanging trees and shrubs. In fact, 90% of the food in the forested streams comes from bordering vegetation.

(3) Protection of Streambanks - Many streambanks are stabilized by streambank trees. They anchor banks and prevent erosion during periods of high water. Removing trees and shrubs and substituting shallow rooted grasses can lead to streambank collapse and stream sediment. Bank overhang is created by stream flows undercutting the stream bank and tree roots. Fish can rest, hide from predators, and feed in these protected areas.

(4) Flooding - Healthy SMZs stabilize floodplains. During times of high water, SMZs reduce the velocity of floodwaters. Their dense vegetation and deep humus slow down racing waters. Forest floodplains suffer less damage when SMZs are protected during harvesting activities.

(5) Recreation - The recreational activities that we enjoy in and around streams are many. This includes swimming, fishing, camping, hunting, and backpacking to name a few.

(6) Timber Production - For those who grow and harvest trees, the fact is that trees often grow best in SMZs. Trees respond to those deep, fertile, and moist soils. Logging activities should not be eliminated within SMZs but modified to insure that stream channels and banks are protected from disturbance. SMZs are not timber harvest "keep out" zones, but there are locations where timber harvesting activities must be modified to protect the many benefits mentioned above.

Recommendations

SMZs should be maintained along all perennial streams or where forest disturbances occur and surface runoff will carry sediment loads. SMZs should be maintained around streams, ponds, perennial flowing natural springs, and all springs and reservoirs serving as domestic water supplies. The following best management practices are recommended:

(1) The width of SMZs should be determined depending on the following conditions: slope of land adjacent to stream, soil erodibility, precipitation, knowledge of particular area, sensitivity of stream, etc. These factors can be obtained from soil maps, on-the-ground evaluation and measurements, weather data, etc.

(2) SMZs should be designed on a case-by-case basis. Most important is that SMZs be consistent with stream characteristics and wide enough to protect water quality.

Soil Type	Percent Slope	SMZ Width (each side)
Slightly erodible	0-5	35'
Slightly erodible	5-20	35-50'
Slightly erodible	20+	50-160'
Erodible	0-5	35-50'
Erodible	5-20	80' minimum
Erodible	20+	160' minimum

Table 1. Recommended Widths for Streamside Management Zone

[NOTE: Please contact your local Natural Resources Conservation Service office to determine the erodibility factor of the soil before determining the proper width of the SMZ.]

(3) On relatively flat terrain (0-5%) on slightly erodible soils, the width of an SMZ should be at least 35 feet wide on each side of a stream.

(4) On relative flat terrain (0-5%) on erodible soils, the SMZ width should range between 35 to 50 feet on each side of a stream.

(5) On slightly erodible soils with slopes ranging between 5 and 20 percent, the SMZ width should range between 35 to 50 feet wide on each side of a stream.

(6) On erodible soils with slopes ranging between 5 and 20 percent, the SMZ width should range between 50 to 160 feet on each side of a stream.

(7) On slightly erodible soils with slopes exceeding 20 percent, the SMZ width should be at least 80 feet on each side of a stream.

(8) On erodible soils with slopes exceeding 20 percent, the SMZ width should be a minimum of 160 feet on each side of a stream.

(9) Partial harvesting is acceptable. A minimum of 50% of the original crown cover or 50 square feet of basal area per acre, evenly distributed, should be retained in the SMZ. This may be adjusted to meet on-site conditions.

(10) Clearcutting is always prohibited within the SMZ.

(11) Designate SMZs to provide stream shading, soil stabilization, sediment and water filtering effects, and wildlife habitat.

(12) Strive to protect the forest floor and understory vegetation from unnecessary damage. Do not remove (harvest) trees from banks, beds or slopes if it will destablilize the soil. Trees on the south and west banks provide the most critical shading of water.

(13) Access roads should cross perennial or intermittent streams at or near a right angle.

(14) Drainage structures such as ditches, cross drain culverts, water bars, rolling dips, and broad-based dips should be used on all roads prior to their entrance into an SMZ to intercept and properly discharge runoff waters.

(15) SMZs may be desirable on intermittent streams for large drainage areas where wildlife is a major landowner concern or for other reasons.

5.0 Fencing

(1) Fencing out livestock, pigs, and other animals in certain areas will help to prevent water quality degradation of streams, protect threatened and endangered plants, reduce soil compaction and maintain soil productivity. Fencing is applicable where desired forest reproduction, soil hydrologic values, existing vegetation, aesthetic values, and recreation are prevented or damaged by these animals.

(2) Pastures should be fenced separately from woodlands. Consider maintenance as well as ease of construction when planning a fence location. By taking advantage of natural barriers such as cliffs, the cost of animal exclusion can be reduced. Also consider use of fences to protect vegetation that provides wildlife food and cover.

(3) Fences should be permanent stock fences built in accordance with good construction principles and workmanship.

6.0 Wildfire Damage Control and Reclamation/Prescribed Burn

The prevention, control, and extinguishment of all wildfires on grass, brush, and watershed lands and the implementation of a prescribed fire program is a desirable goal. Where wildfires do occur, the first and foremost concern is to control the fire and limit the damage. Fire suppression activities can add to the problem of water quality protection.

The loss of vegetative cover, destruction of soil-holding feature of root masses, the exposure of bare mineral soil, is a combination that makes the area burned a highly erodible one. The effects of suppression efforts and equipment operations necessary to control and stop the fire can magnify the erosion problem.

The following are best management practices for wildfire control and reclamation:

(1) The first and foremost concern in wildfire control is to prevent harm or damage to people and property. Fireline best management practices should incorporate minimum impact strategies, which meet land and resource management objectives;

(2) Areas with bare mineral soils should be revegetated and areas where vegetative cover has been killed or severely degraded should be regenerated with plant species appropriate for the soil conditions;

(3) First priority for revegetation/reforestation should be given to banks of surface water bodies so that the SMZ is reestablished;

(4) Firelines should be stabilized and, if necessary, revegetated. Erodible areas altered by suppression equipment activities should be repaired and revegetated as necessary;

(5) Access road surfaces should be repaired and stabilized as necessary.

(6) Whenever possible, avoid using fire suppression chemicals over watercourses and prevent their runoff into watercourses. Do not clean application equipment in watercourses or locations that drain into watercourses.

(7) Provide advance planning and training for firefighters that considers water quality impacts when fighting wildfires. This can include increasing awareness so direct application of fire suppression chemicals to waterbodies is avoided and firelines are appropriately placed.

(8) Include rehabilitative practices as part of suppression and post-suppression tactics and strategies to mitigate non-point source pollution.

6.1 Fireline Construction and Maintenance

Fireline construction and maintenance is an essential part of forest and other land management activities. It deals with site preparation burning, prescribed burning, and wildfire defense and control. A number of control practices can be implemented during fireline construction to prevent unnecessary erosion. Periodic inspection and proper maintenance can prevent potential erosion on established firelanes. The following are best management practices for fireline construction and maintenance:

(1) Firelines should be constructed on the perimeter of the burn area and along the boundary of the Streamside Management Zone. The purpose of protecting the Streamside Management Zone from fire is to safeguard the filtering effects of the litter and organic matter;

(2) Firelines should follow the guidelines established for logging trails and skid trails with respect to waterbars and wing ditches, and should be only as wide and as deep needed to permit safe prescribed burns or fire suppression needs;

(3) Firelines which would cross a drainage should be turned parallel to the stream or have a wing ditch or other structure allowing runoff in the line to be dispersed rather than channeled directly into the stream.

(4) All firelines should be assessed after the fire is controlled for appropriate stabilization, and if necessary, proper rehabilitation should be done while equipment and people are in place.

6.2 Prescribed Burn

(1) Intense prescribed fire for site preparation shall be conducted only if it achieves desired results with minimum impacts to water quality.

(2) Burning on steep slopes or highly erodible soils should be conducted when they are absolutely necessary and should follow carefully planned prescriptions.

(3) Carefully plan burning to adhere to time of year, weather, topography, and fuel conditions that will help achieve the desired results and minimize impacts on water quality. With proper planning, prescribed fires should not cause excessive sedimentation due to the combined effect of removal of canopy species and the loss of soil-binding ability of the subcanopy and herbaceous vegetation roots, in streamside vegetation, small ephemeral drainages, or on very steep slopes.

(4) Site preparation burning creates the potential for soil movement. Burning in the SMZ reduces the filtering capacity of the litter. All efforts should be made to plan burns to minimize impacts on the SMZ.

(5) All bladed firelines, for prescribed fire and wildfire activities, should be built so as to minimize erosion. If necessary, the firelines should be stabilized with water bars and/or other appropriate techniques to control excessive sedimentation or erosion of the fireline. Include any erosion control practices in the construction of firelines.

7.0 Reforestation

Reforestation refers to those operations undertaken to establish a new forest. Site preparation, for the purpose of forest regeneration, is a basic silvicultural tool where for competing vegetation and

reduction of logging debris are necessary. Common site preparation techniques include, manual, mechanical, fire, and herbicides.

Regeneration includes hand and machine planting and direct seeding. Since hand planting and direct seeding pose no water quality problems, BMPs are not necessary. Some mineral soil exposure does occur with machine planting and BMPs are offered.

1) Sites should receive the minimum preparation necessary to successfully control competing vegetation and establish a desirable timber stand. In general, the more intensive the treatment, the more concern for water quality.

2) When working on slopes, mechanical operations such as ripping, shearing, etc., should follow contours.

3) Hand planting, direct seeding or natural regeneration should be used on protected areas adjacent to streams or on slopes too steep to machine plant.

APPENDICES

1. Definition of Terms
2. Road Construction Applications
3. Streamside Management Zone
4. Available Assistance
5. Suggested Readings

definition of terms

DEFINITION of TERMS:

Best Management Practices -- effective, practical, structural or nonstructural methods which prevent or reduce the movement of sediment, nutrients, pesticides and other pollutants from the land to surface or ground water, or which otherwise protect water quality from potential adverse effects of silvicultural activities. These practices are developed to achieve a balance between water quality protection and the production of wood crops within natural and economic limitations.

Bucking -- to saw felled trees into predetermined lengths.

Clearcutting -- the removal of all standing trees within a designated area.

Cross drain -- a cross ditch used to move water from one side of the road to the other side to prevent accumulation of runoff without the need of a culvert or bridge.

Culvert -- a conduit through which surface water can flow under roads.

Diversion ditch - a ditch built across the top of a slope to divert surface water from that slope.

Felling -- the process of severing trees from stumps.

Firebreaks -- naturally occurring or man-made barriers preventing the spread of fire.

Fireline construction -- the construction of a barrier used to prevent the spread of fire.

Intermittent streams -- streams that provide water flow continuously during some seasons of the year but little or no flow during the remainder of the year.

Landing -- an area in the field where logs are collected.

Non-point source -- a source of water pollution which are induced by natural processes, including precipitation, seepage, percolation, and runoff; and not traceable to any discrete or identifiable source.

Perennial streams -- streams which provides water flow at all times except during extreme drought.

Pesticides -- any herbicide, insecticide, or rodenticide, but does not include non-toxic repellents or other chemicals.

Pre-commercial thinning - the removal of selected trees within an established forest destined for commercial use.

Prescribed burning -- the controlled application of fire as a management tool in forest management.

Reforestation -- the successful reestablishment of tree species following harvest.

Silvicultural practices -- all forest management practices, including the establishment, composition, constitution, and growth of forests.

Site preparation -- the removal of unwanted vegetation and other material prior to reforestation.

Skid trails -- routes over which logs are moved to a landing or road.

Streamside Management Zone -- an area on each side of the banks and above the head of intermittent streams, perennial streams, and other drains or bodies of water where extra precaution in carrying out best management practices is needed to protect bank edges and water quality.

Waterbar -- a cross drainage diversion ditch and/or hump in a trail or road for the purpose of diverting surface water runoff into roadside vegetation, duff, ditch, or dispersion area to minimize the volume and velocity which can cause soil movement and erosion.

Wetlands -- geographic areas that are inundated or saturated by surface or groundwater at a frequency or duration sufficient to support (and under normal circumstances do support) a prevalence of vegetation typically adapted for life in saturated soil conditions.

Wing ditch -- a water turnout or diversion ditch constructed to move and disperse water away from the road and side ditches into adjacent undisturbed areas so that the volume and velocity of water is reduce on slopes.

Yarding -- the method of log transport from the harvest area to the storage area.

BROAD BASED DIPS

Definition:

A dip and reverse slope in a truck road surface with an outslope in the dip for natural cross drainage.

Purpose:

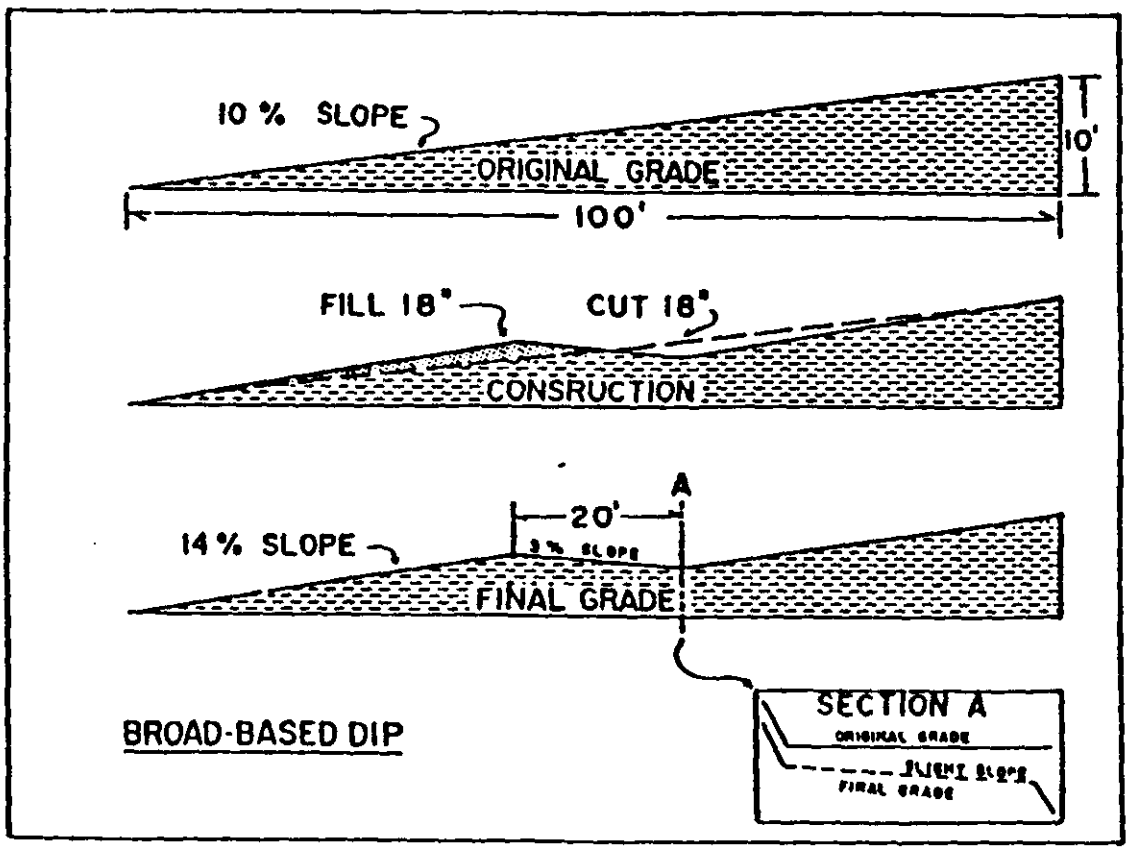
To provide cross drainage on insloped truck roads to prevent build-up of excessive surface runoff and subsequent erosion.

Conditions Where Practice Applies:

Use on truck roads and heavily used skid trails having a gradient of 10% or less. May be substituted for other cross drainage structures where no intermittent or permanent streams are present.

Guidelines:

* Proper construction requires an experienced bulldozer operator.
* Installed after the basic roadbed has been constructed and before major hauling use.



- On grades steeper than 8%, surface dips with stone (approx. 3" diameter) or gravel.
- Use dips on approaches to steep declines in heavily used skid trails.
- Discharge area should be protected with stone, grass sod, heavy litter cover or slash and logs to reduce the velocity and filter the water.

SPACING FOR BROAD BASED DIPS

Road Grade (percent)	Spacing Between Dips (feet)
2	300
4	200
6	165
8	150
10	140
12	130

WATER BARS

Definition:

An earthen or reinforced berm constructed across a truck road or skid trail.

Purpose:

To intercept and divert water from side ditches and truck road or skid trail surfaces, therefore minimizing erosion by decreasing the slope length of surface water flow.

Conditions Where Practice Applies:

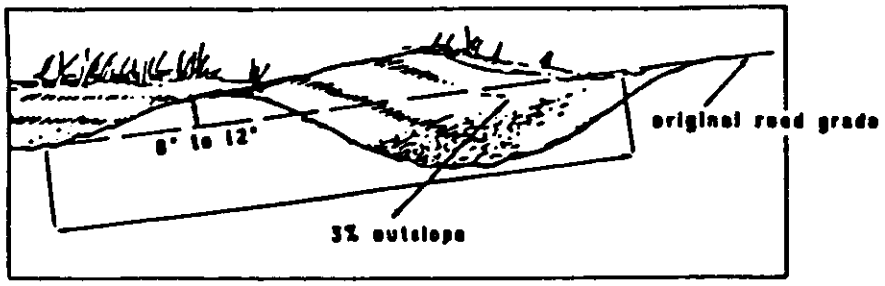
Utilized on any sloping truck road or skid trail where surface water runoff may cause erosion.

Guidelines:

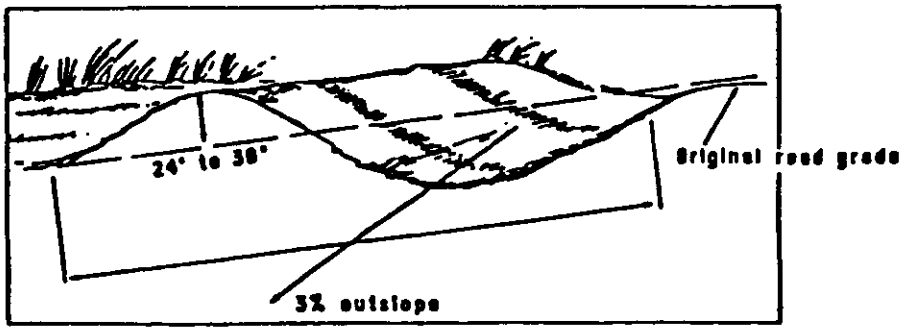
* Start placement of water bars at the farthest skid trail and work back to the log landing and then to the truck road.
* Install water bars with a skidder blade, dozer blade, or by hand.
* Install water bars at the top of any sloping road or trail and at proper spacing along steep sections.

* Water bars may be shallow or deep depending on the need.
* Soil should be left along the lower side of the water bar.
* Should be constructed at a 30° - 35° angle downslope from a line perpendicular to the direction of the truck road or skid trail.
* Should drain at a 3% outslope onto undisturbed litter or vegetation.
* The uphill end of the water bar should extend beyond the side ditch line of the road or trail to fully intercept any water flow.
* The downhill end of the water bar should be fully open and extended far enough beyond the edge of the road or trail to disperse runoff water onto undisturbed forest floor.
* Place rocks, slash, or logs to disperse water coming from a water bar.
* If the road or trail is to be kept open after the harvesting operation, the following guidelines should be used in order to preserve effective water bars.
    - Reinforce the water bars
    - Keep travel to a minimum
    - Use only in dry weather
    - Make frequent inspections
    - Maintain as needed

SHALLOW WATER BAR



DEEP WATER BAR



SPACING FOR WATER BARS

Road/Trail Grade (percent)	Spacing Between Water Bars (feet)
2	250
5	135
10	80
15	60
20	45
30	35

CROSS DRAINAGE CULVERTS

Definition:

Corrugated pipe, well casing, dredge pipe, or other suitable material placed under a truck haul road or major skid road to transmit ditch runoff and seeps from a drainage area of less than 10 acres.

Purpose:

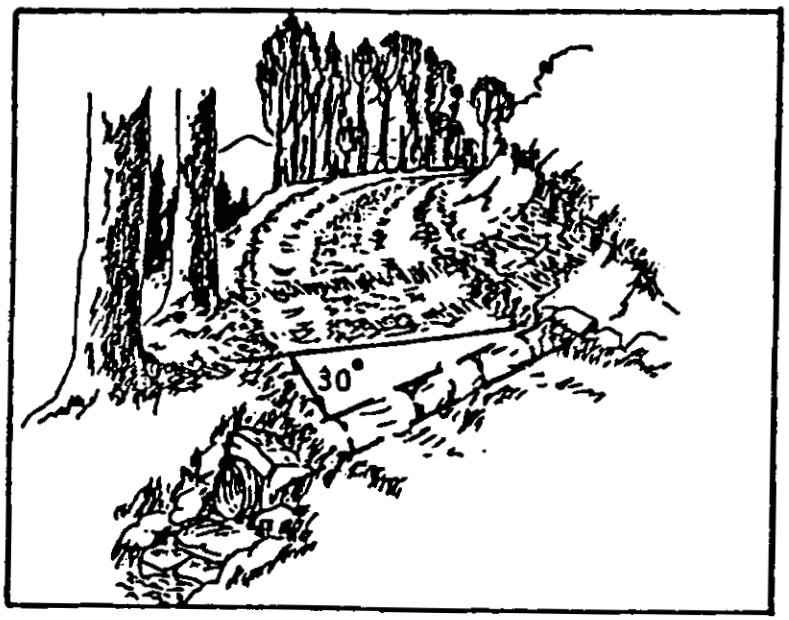
To collect and transmit water flows from side ditches and seeps, under truck haul roads and major skid trails safely without eroding a drainage system or road surface.

Conditions Where Practice Applies:

For any size operation where cross drainage of storm water is required temporarily or permanently.

Guidelines:

* This is the most expensive method of road cross drainage and should be used where heavy road use is anticipated during and after the harvesting operation.



* When sizing culverts for temporary roads, allow for periods of high flow, such as spring runoff or cloudbursts.

* The minimum size culvert to be installed is 12 inch diameter and 20 feet in length.

- When constructing roads on sidehill locations, ditch uphill side of the roadway to intercept surface runoff.

- Allow inlet end of culvert to extend into side ditch so that it intercepts water flowing in the ditch. Construct a berm across the side ditch to assist in diverting water into the culvert.

- Allow outlet end of culvert to extend beyond any fill and empty onto an apron of rock, gravel or logs.

- Space culverts according to road grade:

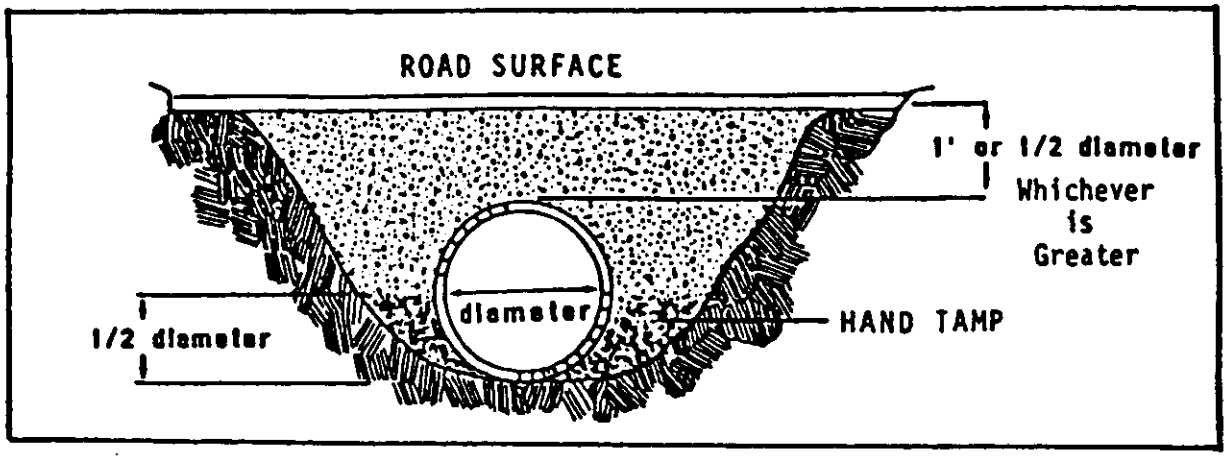
On gentle slopes (1-2%)	300 feet
On moderate slopes (3-10%)	150 feet
On steep slopes (10%+)	100 feet or less

- Culverts should be installed at a 30-35 degree angle downgrade.

- Culverts should be sloped at least 5 inches for every 10 feet of length to permit self-cleaning.

- When harvesting operation has been completed, the road should be stabilized by installing water bars and removing all pipe culverts from truck roads which will not be maintained.

- Culverts, when not maintained, are very likely to become blocked with rocks, ice or other debris. Runoff water can become rerouted over and around the culvert and may wash out sections of road into brooks, streams, ponds or wetlands. It is important to clean culverts regularly. Check after every storm.



- Culvert size selection should be based on the size of the drainage area of a forested watershed and should be able to handle the largest flows.

- Estimating drainage area by taking measurements on a USGS topographic map, using contour lines to define the drainage limits. The Soil Conservation Service can assist you with determination of drainage area.

OPEN TOP CULVERTS

Definition:

A wooden culvert placed across truck haul roads to convey surface runoff and side ditch flows across to downslope side.

Purpose:

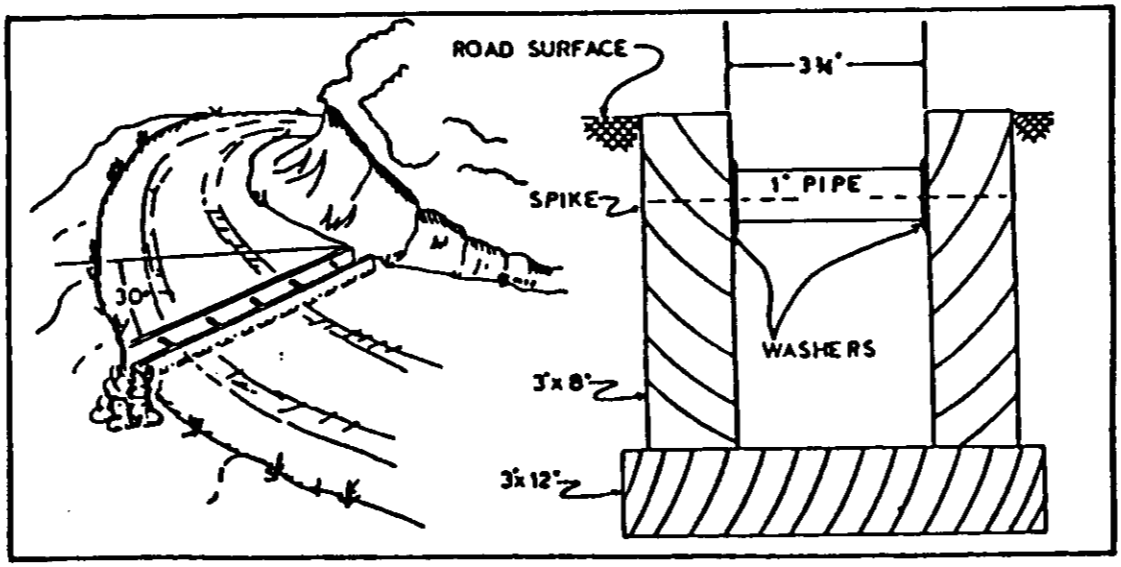
To collect and direct road surface storm runoff and upslope side ditch flows across road without eroding drainage system or road surfaces.

Conditions Where Practice Applies:

This is a temporary drainage structure for on-going harvesting operations. Property built and maintained, it can be used for cross drainage on roads of smaller operations as a substitute for a pipe culvert. This practice should not be used for handling intermittent or live streams or skid trail cross drainage.

Guidelines:

* Can be constructed of cull logs or from sawn lumber. If made of durable wood or treated material, these culverts will give many years of service.



- To be installed flush with the road surface and skewed at an angle not less than 30 degrees downgrade.
- Allow the inlet end to extend into the cut slope or side ditch so that it intercepts water.
- Allow outlet end to extend beyond any fill and empty onto an apron of rock, gravel or logs.
- Open top culverts must be cleaned regularly to remove sediments, gravel, and logging debris to allow normal function of structure at all times.

SPACING FOR OPEN TOP CULVERTS

Road Grade (percent)	Spacing Between Culverts (feet)
2	300
4	200
6	165
8	150
10	140
12	130

road construction applications

OUTSLOPING

Definition:

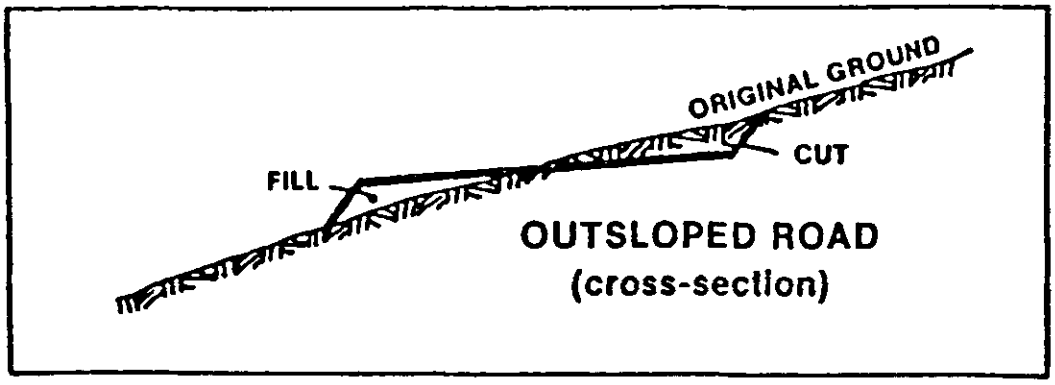
A section of road is sloped slightly (1-3%) from the cut bank to the outside edge of the road bed.

Purpose:

Effective way of limiting erosion because water is removed from the road surface quickly and diverted on to the forest floor.

Condition Where Practice Applies:

Used when the area is entirely rock, or when water can be diverted on to undisturbed forest floor.



INSLOPING

Definition:

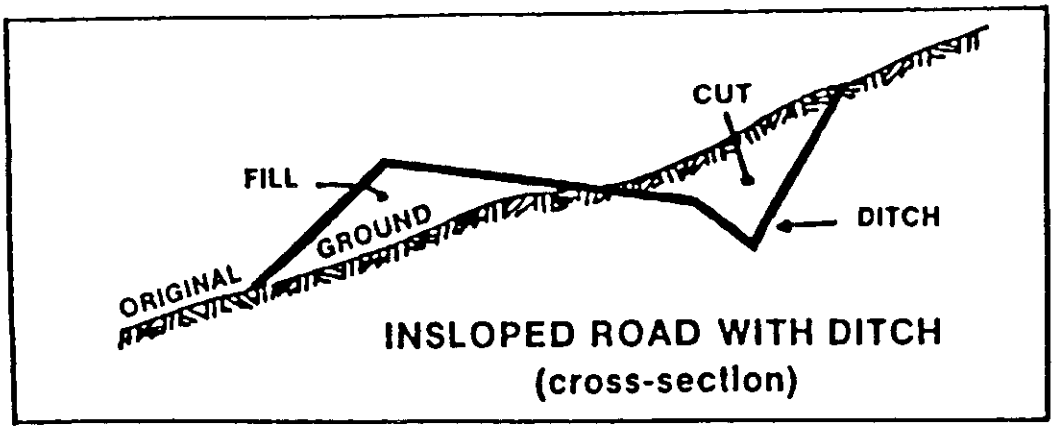
A section of road is sloped slightly (1-3%) toward the cut bank.

Purpose:

Effective way of limiting erosion because water is removed from the road surface quickly and diverted directly to the inside ditch which will carry the water into a culvert.

Condition Where Practice Applies:

Used when the soils are easily saturated or highly erodible. This will limit the amount of ditch water which will flow on to unstable fills.



CROWNING

Definition:

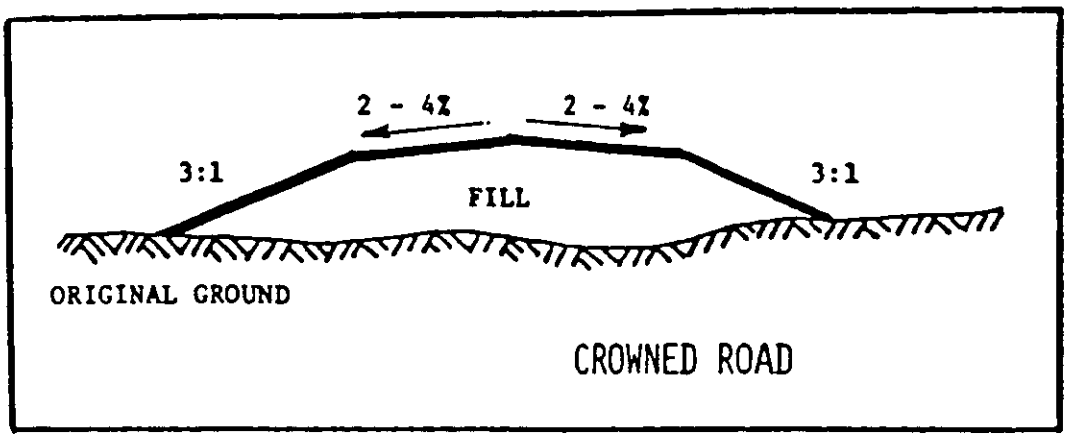
A section of road is sloped slightly (2-4%) from the center line of the road to the outside edges of the roadbed.

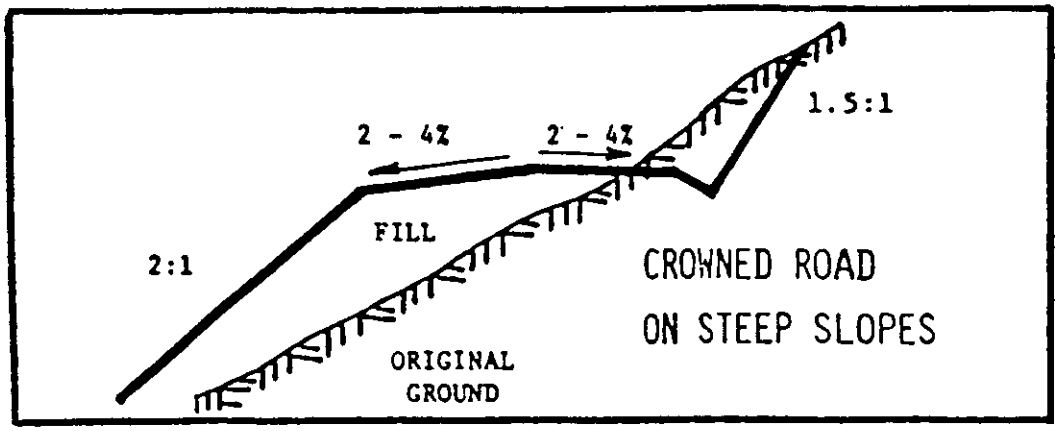
Purpose:

Effective way of limiting erosion because water is removed from the road surface quickly and diverted directly onto the forest floor or into a ditch which will carry the water into a culvert.

Conditions Where Practice Applies:

Used when soils are easily saturated or highly erodible when adjacent areas are relatively level with roadbed or on steep side hills.





streamside management zone

STREAMSIDE MANAGEMENT ZONE

Streamside Management Zones (SMZs) should be maintained along all perennial streams or where forest disturbances occur and surface runoff will carry sediment loads. SMZs should be maintained around streams, ponds, perennial flowing natural springs, and all springs and reservoirs serving as domestic water supplies.

The width of SMZs should be varied, depending on the following conditions: slope of land adjacent to stream, soil erodibility, precipitation, knowledge of particular area, sensitivity of stream, etc. These factors can be obtained from soil maps, on-the-ground evaluation and measurements, weather data, etc.

SMZs should be designed on a case-by-case basis. Most important is that SMZs be consistent with stream characteristics and wide enough to protect water quality.

The following is offered as a guideline:

Soil Type	Percent Slope	SMZ Width (each side)
Slightly erodible	0-5	35'
Slightly erodible	5-20	35-50'
Slightly erodible	20+	50-160'
Erodible	0-5	35-50'
Erodible	5-20	80' minimum
Erodible	20+	160' minimum

[NOTE: Please contact your local Natural Resources Conservation Service office to determine the erodibility factor of the soil before determining the proper width of the SMZ.]

available assistance

Available Assistance

Department of Land & Natural Resources
Division of Forestry and Wildlife
1151 Punchbowl Street, Room 325
Honolulu, HI 96813
Telephone: (808) 587-0166 Facsimile: (808) 587-0160

Hawaii Branch

P.O. Box 4849
Hilo, HI 96720-0849
Telephone: (808) 974-4221
Facsimile: (808) 974-4226

Maui Branch

54 High Street
Wailuku, Hi 96793
Telephone: (808) 984-8100
Facsimile: (808) 984-8111

Oahu Branch

2135 Makiki Heights Drive
Honolulu, HI 96822
Telephone: (808) 973-9778
Facsimile: (808) 973-9781

Kauai Branch

3060 Eiwa Street, Rm. 306
Lihue, HI 96766-1875
Telephone: (808) 274-3433
Facsimile: (808) 274-3438

Natural Resources Conservation Service
Prince Kuhio Federal Bldg., Rm 4-118
Honolulu, HI 96850
Telephone: (808) 541-2600

Hawaii District Offices

Hilo Office
154 Waianuenue Avenue
Hilo, HI 96720
Telephone: (808) 961-5502

Kealakekua Office
P.O. Box 636
Kealakekua, HI 96750
Telephone: (808) 322-2484

Kamuela Office
P.O. Box 1089
Kamuela, HI 96743
Telephone: (808) 885-6602

Pahala Office
P.O. Box 807
Pahala, HI 96777
Telephone: (808) 928-6185

Natural Resources Conservation Service, cont'd.

Maui District Offices

Wailuku Office
70 S. High Street
Wailuku, HI 96793
Telephone: (808) 2444-3729

Molokai Office
P.O. Box 376
Kaunakakai, HI 96748
Telephone: (808) 567-6530

Kauai District Office

Lihue Office
4334 Rice Street, Rm. 104
Lihue, HI 96766
Telephone: (808) 245-6513

Consulting Foresters

Contact the Division of Forestry and Wildlife at (808) 587-0166 for the latest list.

NOTES

Suggested Readings

1. "Logging Roads and Skid Trails, A Guide for Soil Protection and Timber Access," Indiana Department of Natural Resources - Division of Forestry, 21 pp.

2. Dellberg, Robert A., "Road Building for Small Private Roads," Mendocino County Resource Conservation District, Ukiah, CA., July 1992, 73 pp.

3. Walbridge, T.A. Jr., "The Direct Location of Forest Roads," Virginia Polytechnic and State University, Blacksburg, VA., 1990, 70 pp.

4. Walbridge, T.A. Jr., "The Paper Location of Forest Roads," Virginia Polytechnic and State University, Blacksburg, VA., 1990, 75 pp.

5. Walbridge, T.A. Jr., "Field Tables for the Direct Location of Forest Roads," Virginia Polytechnic and State University, Blacksburg, VA., 1991, 15 pp.

6. Wenger, Karl F., "Forestry Handbook, Second Edition," Society of American Foresters, 1984, 1,335 pp.

7. "Erosion and Sediment Control Guide for Hawaii," Soil Conservation Service, 1981, 178 pp.